TECHNICIAN FILE COPY 36937

OPERATING AND SERVICE MANUAL

HP 438A
POWER METER

PRELIMINARY MANUAL
SEE INSIDE COVER FOR MAILER

HEWLETT PACKARD

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

IMPORTANT

PLEASE NOTE THAT WE CANNOT SEND YOU YOUR FINAL MANUAL UNLESS YOU SEND US THIS CARD.

438A

POWER METER

This Preliminary Manual is supplied to permit earliest possible delivery of your instrument. The information is as complete as possible at this time.

This request card entitles you to one copy of the final Operating and Service Manual for this instrument. To receive your copy of the final manual when it is available, fill out, detach and return the card (no postage necessary when mailed in the United States).

Type or print your full name and address in the spaces provided. Be sure to enter the full serial number of the instrument, and mail this card within six months of the date you received your instrument.

PLEASE GIVE US YOUR COMPLETE ADDRESS. PARTIAL ADDRESSES CAUSE DELAYS AND MAY EVEN MAKE IT IMPOSSIBLE FOR US TO FILL YOUR REQUEST.

SEND THIS CARD

CARD MAILED

____/____/____

5950-6163

MANUAL REQUEST

Send final Operating and Service Manual for Model No. 438A

COMPLETE SERIAL NO. ☐☐☐☐☐☐☐☐☐☐

SHIPPING INFORMATION

Please Print

NAME OF ADDRESSEE (Nom du destinataire)

COMPANY NAME (Raison Sociale [Nom de la compagnie])

STREET AND NUMBER (Rue et numero)

CITY, PROVINCE, STATE, ZIP CODE, ETC. (Ville, Province, Department, etc.)

COUNTRY (Pays)

HP cannot guarantee delivery of final manual unless this card is mailed within six months of instrument delivery.

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 201 PALO ALTO, CALIFORNIA

Postage will be paid by:

HEWLETT-PACKARD COMPANY

ATTN: SPD Publications

1501 Page Mill Road

Palo Alto, California 94304

OPERATING AND SERVICE MANUAL

HP 438A
POWER METER
(Including Option 002)

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 2333A.

For additional important information about serial numbers, see INSTRUMENTS COVERED BY THIS MANUAL in Section I.

HEWLETT PACKARD

© Copyright HEWLETT-PACKARD COMPANY 1983
1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

OPERATING AND SERVICE MANUAL PART NO. 00438-90009

Printed: MAY 1984

CONTENTS

Page

Section I
GENERAL INFORMATION

Introduction 1-1
Specification 1-1
Safety Considerations 1-1
Instruments Covered by This Manual 1-1
Description 1-2
Options 1-2
  Electrical Option 1-2
  Mechanical Option 1-2
Accessories Supplied 1-2
Accessories Available 1-2
  Rack Mounting Kits 1-2
  Cables 1-3
Recommended Test Equipment 1-3

Section II
INSTALLATION

Introduction 2-1
Initial Inspection 2-1
Preparation For Use 2-1
  Power Requirements 2-1
  Line Voltage and Fuse Selection 2-1
  Power Cable 2-2
  HP-IB Address Selection 2-3
  Interconnections 2-3
  Mating Connectors 2-3
  Operating Environment 2-3
  Bench Operation 2-5
  Rack Mounting 2-5
Storage and Shipment 2-5
  Environment 2-5
  Packaging 2-5

Section III
OPERATION

Introduction 3-1
  Operating Characteristics 3-1
  Local Operation 3-1
  Remote Operation 3-1
  Operator's Checks 3-1
  Operator's Maintenance 3-1
Turn-On Instructions 3-1
  Turn-On 3-5
  Error Messages 3-5
  Power Reference and Calibration 3-5
Operator's Checks 3-5
  Basic Functional Checks 3-6
  HP-IB Functional Checks 3-9
Remote Operation, Hewlett-Packard Interface Bus 3-17
  HP-IB Compatibility 3-17
  Remote Mode 3-17
  Local Mode 3-17
  Addressing 3-18
  Turn-on Default Conditions 3-18
  Data Messages 3-18
  Receiving the Data Message 3-18
  Sending the Data Message 3-21
  Receiving the Clear Message 3-22
  Receiving the Trigger Message 3-22
  Receiving the Remote Message 3-24
  Receiving the Local Message 3-24
  Receiving the Local Lockout Message 3-24
  Receiving the Clear Lockout/Set Local Message 3-24
  Receiving the Pass Control Message 3-25
  Sending the Require Service Message 3-25
  Sending the Status Byte Message 3-25
  Sending the Status Bit Message 3-26
  Receiving the Abort Message 3-26
  HP-IB Syntax and Characteristics Summary 3-26
Cal Adj 3-28
Cal Factor 3-30
dBm/Watt 3-32
Error Messages 3-34
Filters 3-38
Limits 3-41
Offset 3-43
Preset 3-46
Range 3-47
Recorder Output 3-49
Rel (Relative Measurements) 3-50
Sensor A and Sensor B 3-51
Sensor A—B and Sensor B—A 3-52
Sensor A/B and Sensor B/A 3-54
Set A and Set B 3-56
Store and Recall 3-57
Zero 3-59

Section IV
PERFORMANCE TESTS

Introduction 4-1
Equipment Required 4-1
Performance Test Record 4-1
Performance Tests 4-1
Calibration Cycle 4-1
Abbreviated Performance Test 4-1
Test Procedures 4-1
Zero Carryover Test 4-2
Instrument Accuracy Test 4-4
Power Reference Level Test 4-6

CONTENTS (cont'd)

Page

Section V
ADJUSTMENTS

Introduction 5-1
Safety Considerations 5-1
Equipment Required 5-1
Factory Selected Components 5-1
Interrelated Adjustments 5-1
Post-Repair Adjustments 5-1
±15 Volt Power Supply Adjustment 5-3
+5 Volt Power Supply Adjustment 5-4
Analog to Digital Converter Slope Adjustment ... 5-5
220 Hz Frequency Adjustment 5-7
Ranges 4 and 5 Shaper Adjustment, Channel A and B 5-8
Power Reference Oscillator Frequency Adjustment 5-9
Power Reference Oscillator Level Adjustment ... 5-10

Section VI
REPLACEABLE PARTS

Introduction 6-1
Abbreviations 6-1
Replaceable Parts List 6-1
Factory Selected Parts (*) 6-1
Parts List Backdating (†) 6-1
Parts List Updating (Change Sheet) 6-1
Illustrated Parts Breakdown 6-1
Ordering Information 6-1

Page

Recommended Spares List 6-2
Restored Assemblies 6-2

Section VII
MANUAL CHANGES

Introduction 7-1

Section VIII
SERVICE

Introduction 8-1
Service Sheets 8-1
Block Diagrams 8-1
Schematic Diagrams 8-1
Safety Considerations 8-1
Before Applying Power 8-1
Warnings and Cautions 8-1
Recommended Test Equipment and Accessories 8-2
Service Tools, Aids, and Information 8-2
Service Tools 8-2
Assembly Locations 8-2
Parts and Cable Locations 8-2
Test Point and Adjustment Locations 8-2
Service Aids on Printed Circuit Boards 8-2
Other Service Documents 8-2
Troubleshooting 8-3
Service Related Error Messages 8-3
After Service Safety Checks 8-3

ILLUSTRATIONS

Figure Page

1-1. HP Model 438A Power Meter with Accessories Supplied 1-0

2-1. Line Voltage and Fuse Selection 2-2
2-2. Power Cable and Plug Part Numbers 2-2
2-3. Hewlett-Packard Interface Bus Connections 2-4

⚠ 3-1. Simplified Front Panel Features 3-2
3-2. Rear Panel Features 3-4
3-3. Front Panel Checks Setup (1) 3-7
3-4. Front Panel Checks Setup (2) 3-8
3-5. HP-IB Functional Checks Setup 3-9
3-6. Status Message Information 3-23
3-7. The Status Byte and Service Request Mask 3-25
3-8. Test Setup for Recording Swept Measurements 3-49

Figure Page

4-1. Zero Carryover Test Setup 4-2
4-2. Instrument Accuracy Test Setup 4-4
4-3. Power Reference Level Test Setup 4-6

5-1. Power Supply Adjustments Setup 5-3
5-2. Analog to Digital Converter Slope Adjustment Setup 5-5
5-3. 220 Hz Frequency Adjustment Setup 5-6
5-4. Ranges 4 and 5 Shaper Adjustment Setup .. 5-7
5-5. Power Reference Oscillator Frequency Adjustment Setup 5-8
5-6. Power Reference Oscillator Level Adjustment Setup 5-9

6-1. Front Panel Illustrated Parts Breakdown 6-21
6-2. Rear Panel Illustrated Parts Breakdown 6-22
6-3. Cabinet Parts 6-21

ILLUSTRATIONS (cont'd)

Figure		Page
8-1.	Power Meter Simplified Overall Diagram	8-12
8-2.	Interrupt Control Routine Flowchart	8-13
8-3.	Task 1 Flowchart	8-13
8-4.	Task 2 Flowchart	8-14
8-5.	Simplified Power Supply Grounding	8-16
8-6.	Power Meter Service Position	8-17
8-7.	Display Enable Waveform	8-18
8-8.	Ramp End Waveform	8-19
8-9.	Overall Block Diagram	8-19
8-10.	Service Function Switch	8-20
8-11.	Controller Section Block Diagram	8-21
8-12.	Simplified Power Sensor and Input Amplifier Diagram	8-22
8-13.	Simplified Zeroing Block Diagram	8-22
8-14.	Simplified Analog to Digital (A/D) Converter Block Diagram	8-22
8-15.	Selected Amplified AC	8-23
8-16.	Phase Detector Drive	8-23
8-17.	Amplifier Section Block Diagram	8-23
8-18.	Keyboard Assembly Component Locations	8-24
8-19.	HP-IB Connector Board Assembly Component Locations	8-24
8-20.	P/O Central Processing Unit Assembly Component Locations	8-25
8-21.	Data Input/Output Circuits Schematic Diagram	8-25
8-22.	P/O Central Processing Unit Assembly Component Locations	8-27
8-23.	Microprocessor and Memory Circuits	8-27
8-24.	P/O Central Processing Unit Assembly Component Locations	8-29
8-25.	Timer and Peripheral Interface Adapter (PIA) Circuits Schematic Diagram	8-29
8-26.	P/O Central Processing Unit Assembly Component Locations	8-31
8-27.	Display Driver Circuits Schematic Diagram	8-31
8-28.	Display Assembly Component Locations	8-33
8-29.	Front Panel Display Circuits Schematic Diagram	8-33
8-30.	Input Amplifier Assembly Component Locations	8-35
8-31.	Input Amplifier Circuit Schematic Diagram	8-35
8-32.	P/O Main Amplifier Assembly Component Locations	8-37
8-33.	P/O Main Amplifier Circuits Schematic Diagram	8-37
8-34.	P/O A5 Main Amplifier Assembly Component Locations	8-39
8-35.	P/O Main Amplifier Circuits Schematic Diagram	8-39
8-36.	Rectifier Assembly Component Locations	8-40
8-37.	P/O Interconnect Assembly Component Locations	8-41
8-38.	Regulator Assembly Component Locations	8-41
8-39.	P/O Power Supply Circuits Schematic Diagram	8-41
8-40.	P/O Interconnect Assembly Component Locations	8-43
8-41.	P/O Power Supply Circuits Schematic Diagram	8-43
8-42.	G1A1 Power Reference Oscillator Assembly Component, Test Point, and Adjustment Locations	8-44
8-43.	Power Reference Oscillator Circuits Schematic Diagram	8-45
8-44.	Internal Top View	8-47
8-45.	Internal Bottom View	8-48

TABLES

Table		Page
1-1.	Specifications	1-4
1-2.	Supplemental Characteristics	1-6
1-3.	Recommended Test Equipment	1-7
1-4.	Service Accessories	1-7
2-1.	Fuse Ratings and Part Numbers	2-2
2-2.	ASCII Address Codes to Decimal Equivalents	2-3
3-1.	Major Operating Characteristics	3-1
3-2.	Index of Detailed Operating Instructions	3-1
3-3.	Message Reference Table	3-15
3-4.	Learn Mode #1 Output Format	3-22
3-5.	Response to a Clear Message (and PRESET)	3-24
3-6.	Response to a Trigger Message	3-24
3-7.	HP-IB Codes to Parameter Summary	3-27
3-8.	Error Messages	3-35
3-9.	PRESET Conditions	3-46
4-1.	Performance Test Record	4-9
5-1.	Factory Selected Components	5-1
5-2.	Post-Repair Adjustments, Tests, and Checks	5-2
6-1.	Part Numbers for Restored Assemblies	6-2
6-2.	Reference Designations and Abbreviations	6-3
6-3.	Replaceable Parts	6-5
6-4.	Code List of Manufacturers	6-24
8-1.	Etched Circuit Soldering Equipment	8-3
8-2.	Schematic Diagram Notes	8-4
8-3.	Power Displayed for 1 mW Power Reference	8-19
8-4.	Test Switch Pattern	8-20
8-5.	Data Bus Test Pattern	8-20

SAFETY CONSIDERATIONS

GENERAL

This product and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

This product is a Safety Class I instrument (provided with a protective earth terminal).

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

SAFETY EARTH GROUND

An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set.

WARNINGS

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection.) In addition, verify that a common ground exists between the unit under test and this instrument prior to energizing either unit.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

Servicing instructions are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay, etc.). Do not use repaired fuses or short circuited fuseholders.

SAFETY SYMBOLS

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (see Table of Contents for page references).

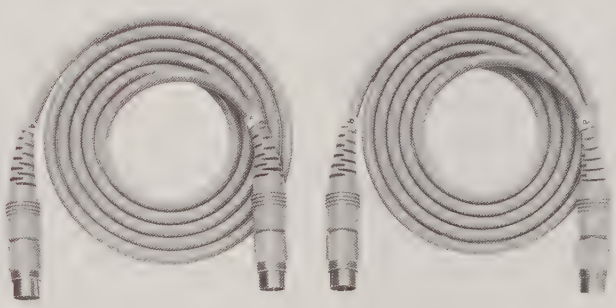
Indicates hazardous voltages.

Indicates earth (ground) terminal.

WARNING The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

HP 438A



POWER SENSOR CABLES

LINE POWER CABLE

Figure 1-1. HP Model 438A Power Meter with Accessories Supplied

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

This manual contains information required to install, operate, test, and service the Hewlett-Packard Model 438A Power Meter. The Power Meter is shown in Figure 1-1 with all of its externally supplied accessories. This manual also documents Option 002 which adds the capability of rear panel sensor inputs and a second reference oscillator output.

This section of the manual covers the instrument description, options, accessories, specifications, and other basic information. The remaining sections cover the following information.

Section II Installation

Section III Operation

Section IV Performance Tests

Section V Adjustments

Section VI Replaceable Parts

Section VII Manual Changes

Section VIII Service

Two copies of the operating information are supplied with the Power Meter. One copy is in the form of an Operating Manual and is simply a copy of the first three sections of the Operating and Service Manual. It should remain with the instrument for use by the operator. The other copy provided is the Operating and Service Manual which should be retained by the technicians responsible for the periodic servicing of the instrument. Additional copies of either manual may be ordered through your nearest Hewlett-Packard sales office. The part numbers are listed on the title page of this manual.

The Operating and Service Manual is also available in microfiche form, and the microfiche part number is listed on the title page. This number may be used to order the 100 X 150 mm (4 by 6 inch) microfilm transparencies. Each transparency contains up to 98 photo-duplicates of the manual pages and the package includes the latest manual change supplements.

1-2. SPECIFICATIONS

Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument may be tested. Supplemental characteristics are listed in Table 1-2. Supplemental characteristics are not warranted specifications, but are typical characteristics included as additional information for the user.

1-3. SAFETY CONSIDERATIONS

This product is a Safety Class I instrument (i.e., provided with a protective earth terminal). The Power Meter and all related documentation must be reviewed for familiarization with safety markings and instructions before operation. Refer to the Safety Considerations page found at the beginning of this manual for a summary of the safety information. Safety information pertinent to the task at hand (installation, performance testing, adjustment, or service) will be found throughout the manual.

1-4. INSTRUMENTS COVERED BY THIS MANUAL

This instrument has a two-part serial number in the form of 0000A00000. The number is stamped on the serial number plate attached to the rear panel of the instrument. The first four digits and the letter constitute the serial number prefix, and the last five digits form the suffix. The prefix is the same for all identical instruments, and it changes only when a change is made to the instrument. The suffix, however, is assigned sequentially and is different for each instrument. The contents of this manual apply directly to instruments having the same serial number prefix(es) as listed under Serial Numbers on the title page.

An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial number prefix indicates that the instrument is different from those documented in the manual. The manual for a newer instrument is accompanied by

INSTRUMENTS COVERED BY THIS MANUAL (cont'd)

a yellow Manual Changes supplement which contains the change information that explains how to adapt the manual to the newer instrument.

In addition to change information, the supplement may contain information for correcting errors in the manual. In order to keep your manual as current and accurate as possible, it is recommended that you periodically request the latest Manual Changes supplement. The supplements are identified with the manual print date and part number, both of which appear on the manual title page. Complimentary copies of the supplements are available from Hewlett-Packard.

For information concerning a serial number prefix that is not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

1-5. DESCRIPTION

The Hewlett-Packard Model 438A Power Meter is a microprocessor controlled dual channel (A and B multiplexed) meter. It measures power in the range of −70 to +44 dBm over the frequency range of 100 kHz to 26.5 GHz using the existing Hewlett-Packard 8480 series power sensors. A 1.00 mW 50 MHz POWER REF (reference) is available for calibrating the meter to the sensor's sensitivity.

The meter displays power in the following modes; dBm, dB Rel (relative), watts and % Rel (per cent relative). The measured ratio and difference of two inputs can be displayed. The power ratio is displayed in either dB or % while the power difference is displayed in either watts or dBm. The ratio or difference power readings of a single sensor input are displayed relative to a stored reference. Also displayed are the possible error states of the meter.

Zeroing, calibration, and offsets are capabilities of the meter that can be set either locally by the front panel keys or remotely over the Hewlett Packard Interface Bus (HP-IB). When these routines are finished the meter resumes measuring and displaying the input power.

The meter has both manual and automatic ranging. In the AUTO RANGE mode the meter automatically switches through its five ranges and in the MNL RANGE (manual range) mode one of the five ranges can be selected.

Memory capacity for saving up to 19 front panel settings is built into the meter and can be accessed by using the STORE and RECALL keys.

1-6. OPTIONS

1-7. Electrical Option

Option 002 provides the additional capability of having two power input connectors on the rear panel in parallel with the front panel inputs and a rear panel connector for an additional power reference oscillator .

Option 004 deletes the two HP 11730A sensor cables normally supplied with the power meter. Refer to cables in this section for other cables available.

1-8. Mechanical Option

A mechanical option kit is available containing hardware and installation instructions for adding handles to the meter. To obtain front handle kit Option 907 order HP part number 5061-0088.

1-9. ACCESSORIES SUPPLIED

The accessories supplied with the Power Meter are shown in Figure 1-1. The line power cable will be supplied in one of several configurations, depending upon the country of destination for the original shipment from the factory. Refer to Power Cables in Section II of this manual. Two power sensor cables, HP part number 11730A, are supplied.

1-10. ACCESSORIES AVAILABLE

1-11. Rack Mounting Kits

These kits are very useful when the Power Meter is to be rack mounted. It permits access to internal circuits and components, and access to the rear panel is possible without removing the instrument from the rack.

Rack mounting one meter. Order HP part number 5061-0072 which includes one rack flange and one extension adapter.

Rack mounting two meters. Order the following: HP part number 5061-0074 two rack flanges, and HP part number 5061-0094 cabinet locking hardware.

Rack mounting one meter with slides. Order the following: HP part number 5061-0096 support shelf, HP part number 1494-0041 two slides, and HP part number 5061-2022 filler panel.

ACCESSORIES AVAILABLE (cont'd)

Rack mounting two meters with slides. Order the following: HP part number 5061-0096 support shelf, and HP part number 1494-0041 two slides.

1-12. Cables

Power Sensor cables with various lengths are available. The model numbers and lengths are listed below.

HP 11730A	1.5m (5 ft)
HP 11730B	3.0m (10 ft)
HP 11730C	6.1m (20 ft)
HP 11730D	15.2m (50 ft)
HP 11730E	30.5m (100 ft)
HP 11730F	61.0m (200 ft)

1-13. RECOMMENDED TEST EQUIPMENT

Table 1-3 lists the test equipment recommended for use in testing, adjusting, and servicing the Power Meter. If any of the recommended equipment is not available, instruments with equivalent critical specifications may be substituted.

Table 1-1. Specifications (1 of 2)

Electrical Characteristics	Performance Limits	Conditions
METER		
Frequency range	100 kHz to 26.5 GHz	Sensor dependent
Power range	−70 dBm to +44 dBm (100 pW to 25W)	Sensor dependent
Dynamic range	50 dB total range	40 dB full scale in 10 dB steps
Inputs	Channel A and B	Multiplexed dual sensors
Rear panel output	0—1 volt analog	Without digital filtering 1kΩ output impedance BNC connector
Measurement modes	A, B, A-B, B-A, A/B, B/A	Normal or relative all modes
Display units	Watts or dBm Percent or dB Percent or dB	Absolute A, B, A-B, B-A Ratio A/B, B/A Relative
Resolution		
Normal	0.1% full scale 0.01 dB	Auto filter watts or percent dBm or dB
High	0.01% full scale 0.001 dB	Manual filter watts or percent dBm or dB

Highest Power	5	*	*	*	*	*	*	*	0	0	X	* High resolution 0 Normal resolution X Auto filter
RANGE	4	*	*	*	*	*	*	0	0	0	X	
	3	*	*	*	*	*	0	0	0	X	0	
	2	*	*	0	0	0	0	X	0	0	0	
Lowest Power	1	0	0	X	0	0	0	0	0	0	0	
FILTER NUMBER		9	8	7	6	5	4	3	2	1	0	

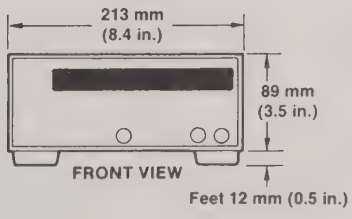
ACCURACY		
Instrumentation, includes sensor linearity[1]		
Single channel mode	±0.02 dB	Within same calibration range
	Plus ±0.02 dB	Outside calibration range
Dual channel mode[2] (ratio or difference)	Multiply single channel specifications by 2	

[1]When operating on the top power range add the Power Linearity percentages of the power sensor.

[2]Accuracy does not depend on the meter being in Normal or Relative mode.

Table 1-1. Specifications (2 of 2)

Electrical Characteristics	Performance Limits	Conditions
ACCURACY (cont'd)		
Zero set (digital settability of zero)	±0.5% full scale	Most sensitive range. Decrease percentage by factor of 10 for each higher range ±1 count
Power reference	1.00 mW	Internal 50 MHz oscillator factory set to ±0.7% traceable to National Bureau of Standards
Power reference accuracy	±1.2% ±0.9%	Worst case RSS for one year.
GENERAL		
Operating temperature range	0° C to 55° C	
Power requirements	65 VA, 35 watts	Maximum
Line voltage	100, 120, 220 or 240 Vac, +5%, −10%	
Line frequency	48 to 66 Hz	All specified line voltages may be used
	360 to 440 Hz	Limited to line voltages of 100 or 120 Vac
Remote operation	HP-IB	All functions except power switch, clear entry, HP-IB address
Compatibility	HP-IB interface	SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP1, DC1, DT1, C0
Memory	Non-volatile	Contains complete meter operating state of both channels plus contents of store/recall registers
Operating and non-operating environment	Temperature, humidity, shock, and vibration type tested to MIL-T-28800B Class V requirements.	
Safety	Meets requirements of IEC 348	
Net weight	5.9 kg (13 lb)	



Dimensions:
89 mm H x 213 mm W x 418 mm D
(3.5 x 8.4 x 16.8 inches)

NOTE: For ordering cabinet accessories, the module sizes are 3-1/2 H, 1/2 MW, and 17D.

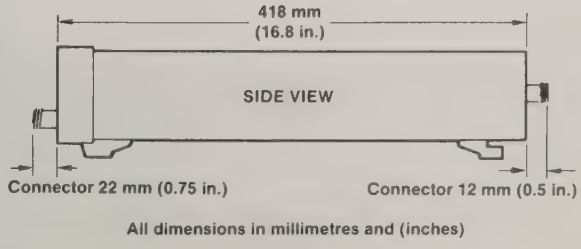


Table 1-2. Supplemental Characteristics

Supplemental characteristics are intended to provide information useful in applying the instrument by giving typical, but non-warranted performance parameters.

METER NOISE

As a % of full scale, with constant temperature, range 1, measured over one minute interval, and two standard deviations.

HP 8481A, 8481B, 8481H, 8482A, 8482B, 8482H, 8483A, 8485A Sensors:

Filter No.	0	1	2	3	4	5	6	7	8	9
Noise (%)	6.0	2.4	1.8	0.90	0.7	0.5	0.4	0.3	0.2	0.15

HP 8484A Sensor: multiply noise levels by 4 for all filters. Decrease noise by a factor of 10 for each higher range for all sensors and all filters.

ZERO DRIFT OF SENSORS

As a % of full scale, 1 hour, at constant temperature after 24 hour warmup.

HP 8481A, 8481B, 8481H, 8482A, 8482B, 8482H, 8483A, 8485A Sensors: ±0.1% of full scale on range 1.

HP 8484A Sensor:
±2.0% of full scale on range 1.

Decrease the above by a factor of 10 for each higher range.

SETTLING TIME

0 to 99% settled readings over the bus. AUTO filter, range hold, 10 dB decreasing power step.

Single channel	<3.0 s	Range 1
	<1.0 s	2
	<150 ms	3
	<100 ms	4—5

MANUAL filter, range hold, 10 dB decreasing power step.

Single channel:

Filter No.	0	1	2	3	4	5	6	7	8	9
Response Time (s)	0.10	0.15	0.25	1.0	1.4	2.2	3.7	6.9	14.0	27.0

Dual channel (ratio or difference mode): approximately the sum of the individual response times of each channel, plus channel switching delay.

MEASUREMENT SPEED

Over HP-IB and free running trigger.
Single channel: 20 readings per second.
Dual channel: 2 readings per second.

CHANNEL SWITCHING DELAY

200 ms.

POWER REFERENCE

Frequency: 50 MHz nominal.
SWR: 1.05 maximum.
Connector: Type N female.

METER ADJUSTMENTS

Cal Factor: Key pad entry or programmable, 1—150% in 0.1% increments.

Zeroing: Front panel or programmable, zeros all 5 ranges, reference oscillator automatically switched off during zeroing.

Cal Adjust: Automatic, front panel or programmable, internal 1.00 mW reference, or external reference oscillator. Reference Cal Factor from 50.0% to 120.0%.

Channel Offset: Front panel or programmable, –99.99 to +99.99 dB in 0.01 dB increments.

Digital Filter Length: Averages power readings from 1 to 512 successive values in increments by factors of two (1, 2, 4, . . . 256, 512). Front panel or programmable.

High/Low Power Limits: Programmable only, activates Service Request and flashing front panel indicator, individual channel values from –299.999 to +299.999 dBm in 0.001 dB increments.

Store/Recall Registers: Nineteen registers to store complete operating state of meter for later recall.

Relative Mode: When activated, displays all successive measurements relative to the last value read when activated. Units are in dB or %.

Table 1-3. Recommended Test Equipment

Instrument	Critical Specifications	Recommended Model	Use[1]
Digital Voltmeter	Range: 0 to 20 Vdc Resolution: 0.01 Volt	HP 3456A	A, T
Oscilloscope	>200 MHz bandwidth	HP 1725A	T
Range Calibrator	Calibration uncertainty ±0.25%	HP 11683A	P, A, T
Signature Multimeter	Qualified Signature Analysis	HP 5005B	T
Frequency Counter	Range: 10 Hz to 50 MHz Resolution: 1 Hz	HP 5328A Option 031	P, A, T
Power Splitter	Frequency: 50 MHz Impedance: 50 Ohms Connectors: Type N	HP 11667A	P, T
Power Meter	Range: 1 mW Transfer Accuracy: 0.2% (Input to Output)	HP 432A	P, A, T
Thermistor Mount	SWR: 1.05 at 50 MHz Accuracy: ±0.5% at 50 MHz	HP 478A-H75[2] or HP 478A-H76[3]	P, A

[1]P = Performance, A = Adjustment, T = Troubleshooting.

[2]Calibrated at the National Bureau of Standards (NBS) for this accuracy.

[3]HP standards lab calibration to ±0.58% at 50 MHz (traceable to NBS).

Table 1-4. Service Accessories

Accessory*	Specification	Suggested Model
Open-End Wrench (SMC Connectors)	1/4-inch	Utica Tool Co.**, Open End Standard, Model No. OP82, 1/4-inch
Extender Board	36 contacts (2 x 18)	HP 08684-60018
Foam Pad	Conductive polyurethane foam, 12 x 12 x 0.25 inches	HP 4204-0094

*Refer to Section VIII, Service, for applications.

**Utica Tool Company, Inc., Orangeburg, SC 29115 or the nearest Utica Tool Company distributor.

SECTION II
INSTALLATION

2-1. INTRODUCTION

This section provides the information needed to install the Power Meter. Included is information pertinent to the initial inspection, power requirements, line voltage and fuse selection, operating environment, instrument mounting, storage, and shipment.

2-2. INITIAL INSPECTION

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers and panels).

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The procedures for checking electrical performance are given in Section IV, Performance Tests. If the contents are incomplete, if there is a mechanical defect, or if the instrument does not pass the performance tests, notify the nearest Hewlett-Packard office. If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier and the Hewlett-Packard office. Keep the shipping material for the carrier's inspection.

2-3. PREPARATION FOR USE

2-4. Power Requirements

WARNING

To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz. Leakage currents at these settings may exceed 3.5 mA.

The Power Meter requires a power source of any voltage between 90 and 126 Vac or between 198 and 252 Vac, 48 to 66 Hz, single phase. The Power Meter has the additional capability of operating with line frequencies of 360 to 440 Hz. However, operation at line frequencies greater than 66 Hz is limited to a line voltage of 90 to 126 Vac. The power consumption is less than 65 VA using either source.

WARNINGS

This is a Safety Class I product (i.e., provided with a protective earth terminal). An uninterruptible safety earth ground must be provided from the Mains power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and secured against any unintended operation.

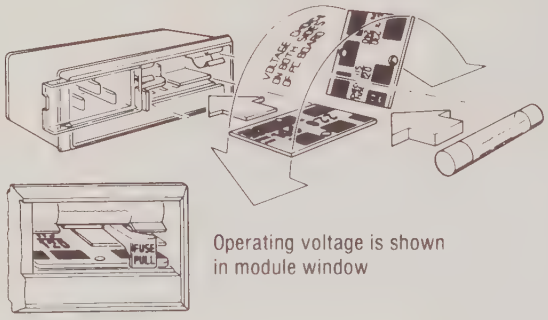
If the instrument is to be energized via an external autotransformer (for voltage reduction), make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

2-5. Line Voltage and Fuse Selection

CAUTION

Before plugging this instrument into the Mains (line) voltage, be sure that the correct operating voltage and fuse have been selected.

A rear-panel line-power module permits operation from 90 to 126 Vac sources or from 198 to 252 Vac sources. The number visible in the window on the module indicates the nominal line voltage (100, 120, 220 or 240 Vac) to which the instrument must be connected. Verify that the line voltage selection card and the fuse are matched to the power source to be used. Refer to Figure 2-1, Line Voltage and Fuse Selection. Table 2-1 lists the ratings and HP part numbers for the replaceable fuses.



SELECTION OF OPERATING VOLTAGE

1. Open cover door, pull the FUSE PULL lever and rotate to left. Remove the fuse.
2. Remove the Line Voltage Selection Card. Position the card so the line voltage appears at top-left corner. Push the card firmly into the slot.
3. Rotate the FUSE PULL lever to its normal position. Insert a fuse of the correct value in the holder. Close the cover door.

WARNING

Do not operate this instrument with frequencies greater than 66 Hz. Line frequencies greater than 66 Hz with line voltages greater than 126.5 Vac will cause a potential shock hazard that could result in personal injury (leakage current at these settings may exceed 3.5 mA). In addition, damage to the instrument may result.

Figure 2-1. Line Voltage and Fuse Selection

WARNING

For protection against fire hazards, the line fuse should be a 250V normal-blow fuse with the correct current rating.

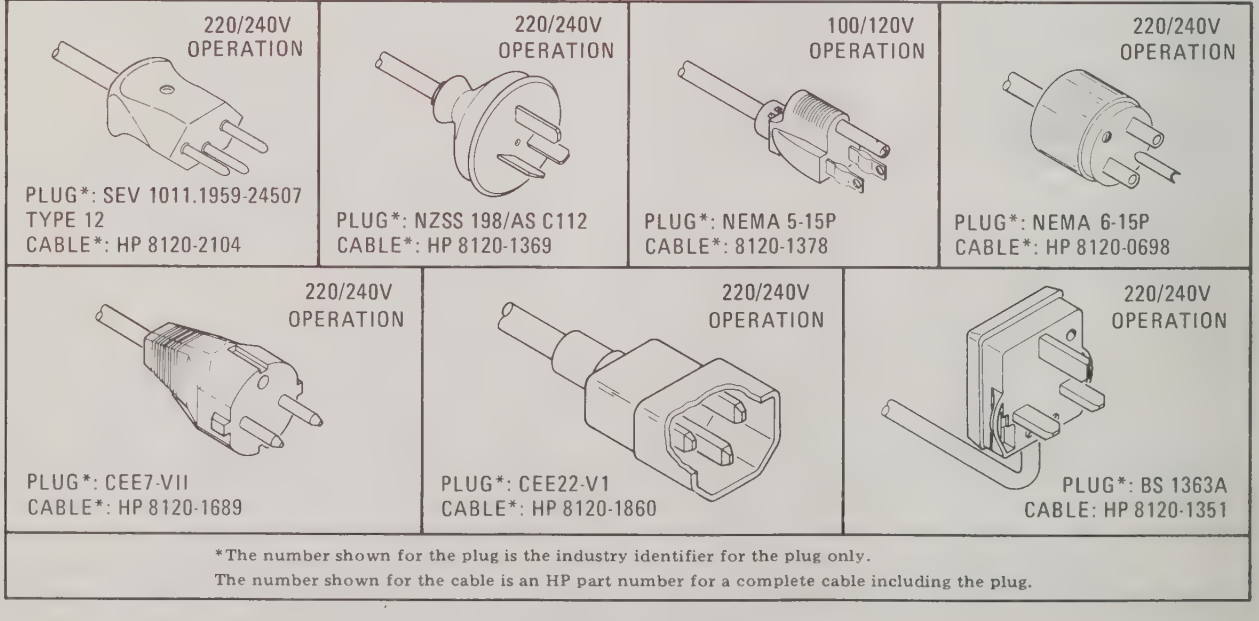
Table 2-1. Fuse Ratings and Part Numbers

Line Voltage	Rating	Part Number
100/120V	1.0A, 250V	2110-0001
220/240V	0.5A, 250V	2110-0012

2-6. Power Cable

WARNING

Before connecting this instrument, the protective earth terminal of the instrument must be connected to the protective conductor of the (Mains) power cord. The Mains plug shall be inserted only in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.



*The number shown for the plug is the industry identifier for the plug only.
The number shown for the cable is an HP part number for a complete cable including the plug.

Figure 2-2. Power Cable and Plug Part Numbers

Power Cable (cont'd)

This instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable plug shipped with each instrument is determined by the country of destination. Refer to Figure 2-2 for the part numbers of the power cables and plugs available.

Table 2-2. ASCII Address Codes to Decimal Equivalents

ASCII Address Codes		Decimal Equivalents
LISTEN	TALK	
SP	@	00
!	A	01
"	B	02
#	C	03
$	D	04
%	E	05
&	F	06
'	G	07
(	H	08
)	I	09
*	J	10
+	K	11
,	L	12
—	M	13
.	N	14
/	O	15
0	P	16
1	Q	17
2	R	18
3	S	19
4	T	20
5	U	21
6	V	22
7	W	23
8	X	24
9	Y	25
:	Z	26
;	[	27
<	\	28
=	]	29
>	^	30

Decimal 13 is the factory set HP 438A address.
Decimal 40—49 is TALK ONLY.
Decimal 50—59 is LISTEN ONLY.

2-7. HP-IB Address Selection

The address can be selected from the front panel and stored in RAM. The procedure for keying in an address from the front panel is to turn the instrument off, then press and hold the LCL (local) key while turning the instrument on, wait for the ENT (enter) address message,release the LCL key then key in the address using the keys representing the numbers. Table 2-2 shows the ASCII address codes to decimal equivalents.

When an address is stored in RAM and not lost, changing the internal HP-IB switch will have no effect. The internal HP-IB address switch is set at the factory to 13. The address that is stored in RAM can be viewed on the front panel display by pressing the LCL (local) key and will be the valid address unless memory is lost. Memory lost is indicated by a RCL (recall) FAIL ERROR message.

2-8. Interconnections

The connection from meter to power sensor is made through HP 11730A through F cables having circular 12 contact male mating connectors. The two front panel connectors (Sensor A and Sensor B), and the two rear panel Option 002 connectors (SENSORS A,B) require this mating connector.

The rear panel interface connector for the Hewlett Packard Interface Bus is a 24 pin connector. The HP-IB mating connector is shown in Figure 2-3. Part numbers for mating connectors are included in the figure. Note the two securing screws are metric.

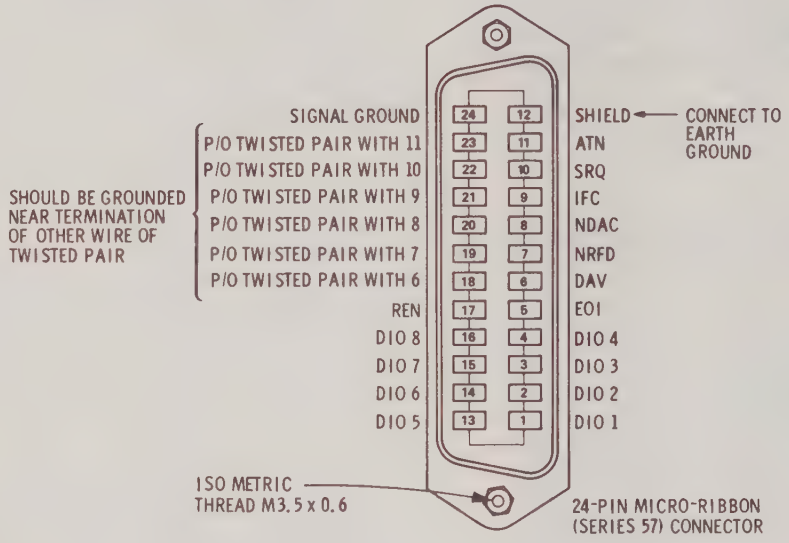
2-9. Mating Connectors

Coaxial Connectors. The front-panel output POWER REF 1.00mW 50 MHz and the rear-panel Option 002 OSC (power reference oscillator) output connectors require 50-ohm type N male mating connectors. The rear panel RCDR (recorder) output signal connector requires a 50-ohm BNC male mating connector. Both types must be compatible with the specifications of US MIL-C-39012. The power reference oscillator connectors are designed to be used with power sensors that have Type N connectors.

2-10. Operating Environment

The operating environment should be within the following limitations:

Temperature ..... 0°C to 55°C
Humidity ..... 40°C at <95% relative
Altitude ..... <4570 metres (15 000 feet)



Logic Levels

The Hewlett-Packard Interface Bus Logic Levels are TTL compatible, i.e., the true (1) state is 0.0 Vdc to +0.4 Vdc and the false (0) state is +2.5 Vdc to +5.0 Vdc.

Programming and Output Data Format

Refer to Section III, Operation.

Mating Connector

HP 1251-0293; Amphenol 57-30240.

Mating Cables Available

HP 10833A, 1 metre (3.3 ft), HP 10833B, 2 metres (6.6 ft)
HP 10833C 4 metres (13.2 ft), HP 10833D, 0.5 metres (1.6 ft)

Cabling Restrictions

1. A Hewlett-Packard Interface Bus system may contain no more than 2 metres (6.6 ft) of connecting cable per instrument.

2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus system is 20.0 metres (65.6 ft).

Figure 2-3. Hewlett-Packard Interface Bus Connections

2-11. Bench Operation

The instrument cabinet has plastic feet and fold-away tilt stands for convenience in bench operation. The plastic feet are designed to ensure proper stacking with other instruments in similar housings, and the tilt stands raise the front of the Power Meter for easier viewing of the front panel.

2-12. Rack Mounting

The Power Meter may be rack mounted using Hewlett-Packard sub-module cabinets. If it is desired to rack mount one Power Meter by itself, order half-module kit, HP Part Number 5061-0072. If it is desired to rack mount two Power Meters or another HP product with the same physical dimensions, side by side, order the following items:

1) Lock Link Kit HP Part Number 5061-0094
2) Rack Mounting Flange Kit.
   HP Part Number 5061-0074

When rack mounting with a support shelf and slide kit order:

1) Shelf HP Part Number 5061-0096
2) Slide Kit HP Part Number 1494-0041

In addition to the rack mounting hardware, a front handle assembly (two provided) is also available for the Power Meter. Order front handle kit Option 907 HP Part Number 5061-0088.

Rack mounting information is provided with the rack mounting kits. If a kit was not ordered as an option or an accessory with the Power Meter, it may be purchased through the nearest Hewlett-Packard office. Refer to Mechanical Options or Mechanical Equipment Available in Section I.

2-13. STORAGE AND SHIPMENT

2-14. Environment

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment.

Temperature ..... −55°C to +75°C
Humidity ..... 40°C at <95% relative
Altitude ..... <15 300 metres (50 000 feet)

2-15. Packaging

Original Packaging. Containers and material identical to those used in factory packaging are available through Hewlett-Packard offices. If the instrument is being returned to Hewlett-Packard for servicing, please complete one of the blue repair tags located at the end of this manual and attach it to the instrument. Be sure to include the type of service required, return address, model number, and full serial number. Mark the container FRAGILE to assure careful handling. In any correspondence concerning a Hewlett-Packard instrument, refer to the instrument by model number and include the full serial number.

Other Packaging. The following general instructions should be followed for repackaging with commercially available packaging materials.

a. Complete one of the blue service tags located at the end of this manual and attach it to the instrument. Be sure to indicate the type of service required, return address, model number, and full serial number. Then wrap the instrument in heavy paper or plastic.

b. Use a strong shipping container. A double-wall carton made of 2.4 MPa (350 psi) test material is adequate.

c. Use enough shock absorbing material (75 to 100 mm or 3 to 4 inch layer) around bottom, top, and all sides to provide a firm cushion and to prevent movement within the container.

d. Seal the shipping container securely.

e. Mark the shipping container FRAGILE to assure careful handling.

SECTION III
OPERATION

3-1. INTRODUCTION

This section provides operating information for the Power Meter. Included in this section are general and detailed operating instructions, descriptions of the front and rear panel, local and remote operator's instructions, and operator's maintenance procedures.

3-2. Operating Characteristics

Table 3-1 briefly summarizes the major operating characteristics of the Power Meter. This table is not intended to be an in-depth listing of all operations and ranges but gives an idea of the instrument's capabilities. For more information on the Power Meter's capabilities refer to Table 1-1, Specifications and Table 1-2, Supplemental Characteristics. For information on HP-IB capabilities, refer to the summary contained in Table 3-3, HP-IB Message Reference Table.

3-3. Local Operation

Initial Turn-On Information. Instructions relating to the Power Meter's turn-on procedure are presented to acquaint the user with the general operation of the instrument.

Information covering front panel operation of the Power Meter is given in the sections described below. To rapidly learn the operation of the instrument, begin with Major Operating Characteristics and Operator's Checks.

Panel Features. Front and rear panel features are described in Figures 3-1 and 3-2. The front panel has different colored keys and lettering for different operating modes. The shift key has yellow lettering and relates to the shifted capablility of the A, B, and B/A keys as shown by the yellow lettering next to these keys. Blue keys, blue numbers and all blue lettering are related and set the Power Meter into its entry mode. When a blue key is pressed the display will show that a Ent (enter) response is required. Also some of the keys have a two letter mnemonic near them. This two letter mnemonic will be used in remote programming of the Power Meter.

Simplified Operating Instructions. The instructions located on the foldout provide a quick introduction to front panel operation of the Power Meter. These instructions are designed to rapidly acquaint the new user with basic operating procedures and therefore are not an exhaustive listing of all Power Meter functions.

Detailed Operating Instructions. The detailed operating instructions provide the operating reference information for the Power Meter user. The instructions are indexed in Table 3-2.

3-4. Remote Operation HP-IB

HP-IB. The Power Meter is capable of remote operation via the Hewlett-Packard Interface Bus (HP-IB). Instructions pertinent to HP-IB operation cover considerations and instructions specific to remote operation including capabilities, addressing, input and output formats, the status byte, and service requests. At the end of the discussion is a complete summary of all codes.

3-5. Operator's Checks

Operator's Checks are procedures designed to verify the proper operation of the Power Meter's main capabilities. Two procedures are provided as described below.

Basic Functional Checks. This procedure requires power sensors, cables, and a power splitter. It assures the operator that most front panel controlled features are being properly executed by the Power Meter.

HP-IB Functional Checks. These procedures require an HP-IB compatible computing controller, an HP-IB interface, and connecting cable. The procedures check the applicable bus messages summarized in Table 3-3. The HP-IB Checks assume that front panel operation has been verified by performing the Basic Front Panel Checks.

3-6. Operator's Maintenance

WARNING

For continued protection against fire hazard, replace the line fuse with a 250V fuse of the same rating only. Do not use repaired fuses or short-circuited fuseholders.

Table 3-1. Major Operating Characteristics

POWER RANGE (Sensor Dependent)	−70 dBm to +44 dBm Auto or Manual 1 through 5 ranges, the power range of each sensor is divided into five parts. ⚠ POWER SENSOR — RANGE HP8481B 0 to +44 dBm (1 mW to 25 W) HP8482B 0 to +44 dBm (1 mW to 25 W) HP8481H −10 to +35 dBm (100 μW to 3 W) HP8482H −10 to +35 dBm (100 μW to 3 W) HP8481A −30 to +20 dBm (1 μW to 100 mW) HP8482A −30 to +20 dBm (1 μW to 100 mW) HP8485A −30 to +20 dBm (1 μW to 100 mW) HP8483A 75 Ohm[1] −30 to +20 dBm (1 μW to 100 mW) HP8484A −70 to −20 dBm (100 pW to 10 μW)
FREQUENCY RANGE (Sensor Dependent)	100 kHz to 26.5 GHz
ZEROING	Calibration of the Power Meter to power sensor sensitivity
CALIBRATION FACTOR (1)	Compensation for mismatch and effective efficiency
POWER REFERENCE	1 mW at 50 MHz
POWER DISPLAY	dBm, dB Relative, Watts, and % Relative
RATIO and DIFFERENCE	Dual Inputs Ratio in dB or % Difference in dBm or Watts
OFFSET	Compensation for gains or losses in test system
DIGITAL FILTERING	Auto or Manual filters 0 through 9 A filter length or number of readings is determined by two being raised to some power where that exponent is the filter number.
MEMORY	19 registers for store and recall of front panel information. A twentieth register is used for recall only of power down information.

[1] When using the 8483A Power Sensor, a special calibration procedure must be used. Older 8483A Power Sensors called for using the reference cal factor, and adjusting the power meter for 0.96 mW to account for the mismatch between the 75Ω power sensor and the 50Ω ref osc output. Since the 438A Power Meter cannot be adjusted to anything other than 1.000 mW, the ref cal factor must be adjusted to accommodate the 4% mismatch. Accordingly, on newer 8483As, the instructions read to set the cal factor to the ref cal factor value and calibrate to 1.000 mW. When using an older 8483A that specifies adjusting to 0.96 mW, the following procedure should be used:

1. Set the ref cal factor to 0.96 times the ref cal factor on the label.
2. The Power Meter will automatically adjust to 1.000 mW. Note that the cal factor value for 50 MHz power measurements should be read from the plotted data on the sensor body. No special procedure is necessary for these measurements.

Table 3-2. Index of Detailed Operating Instructions

Section	Page
Calibration	
CAL ADJ	3-28
ZERO	3-59
Measurement Parameters	
CAL FACTOR	3-30
Filters (Includes AUTO FILTER and MNL FILTER)	3-38
Limits	3-41
OFFSET	3-43
Range (Includes AUTO RANGE and MNL RANGE)	3-47
SET A and SET B	3-56
Measurements	
REL (Relative Measurements)	3-50
SENSOR A and SENSOR B (Single Sensor Measurements)	3-51
SENSOR A−B and SENSOR B−A (Dual Sensor Difference Measurements)	3-52
SENSOR A/B and SENSOR B/A (Dual Sensor Ratio Mesurements)	3-54
Miscellaneous	
dBm/WATT (Logarithmic and Linear Measurement Units)	3-32
Error Messages	3-34
Recorder Output	3-49
STORE and RECALL	3-57

Operator's Maintenance (cont'd)

Operator's maintenance consists of replacing defective fuses. The primary power fuse is located within the Line Power Module Assembly. Refer to Figure 2-1 for instructions on how to change the fuse.

If the instrument does not operate properly and is being returned to Hewlett-Packard for service, please complete one of the blue tags located at the end of this manual and attach it to the instrument. Refer to Section II for packaging instructions.

3-7. TURN-ON INSTRUCTIONS

WARNINGS

Before the instrument is switched on, all protective earth terminals, extension cords, autotransformers and devices connected to it should be connected to a protective earth grounded socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury.

Only 250V normal blow fuses with the required rated current should be used. Do not use repaired fuses or short circuited fuseholders. To do so could cause a shock or fire hazard.

SIMPLIFIED FRONT PANEL FEATURES

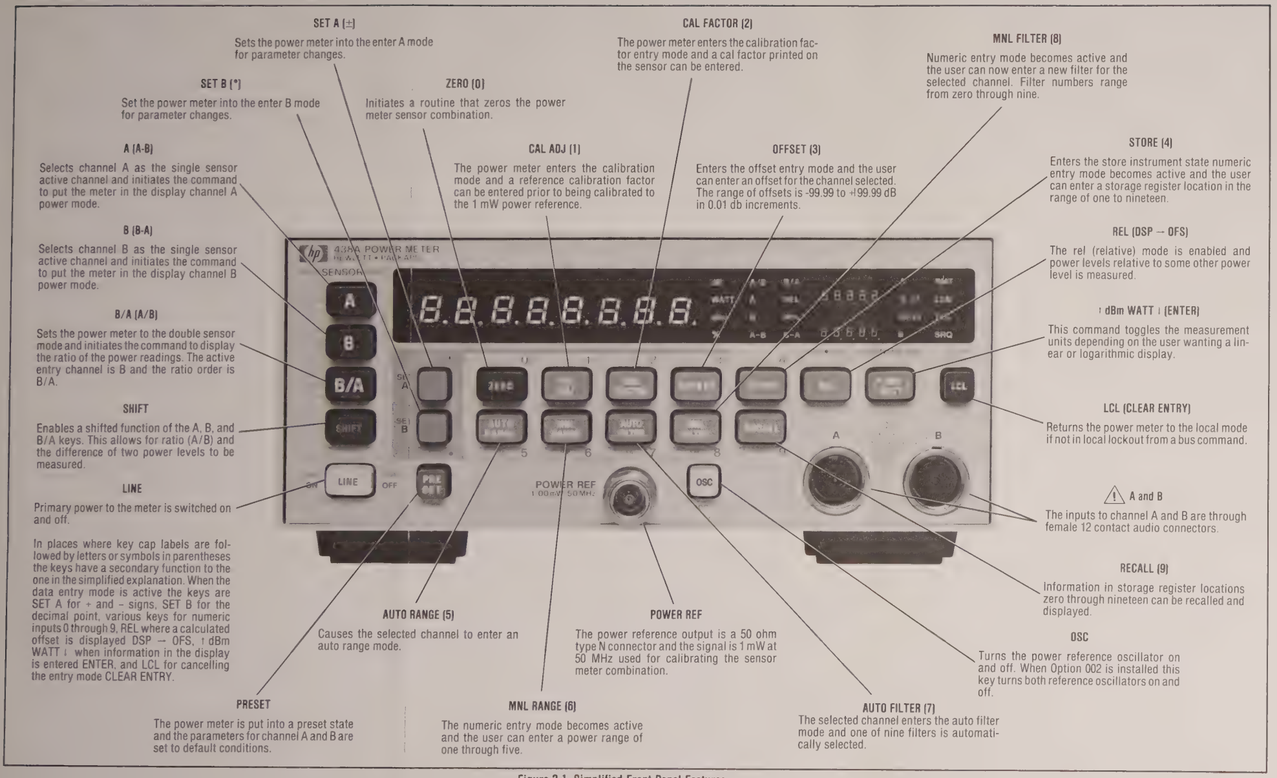

SET A (±)
Sets the power meter into the enter A mode for parameter changes.
SET B (*)
Set the power meter into the enter B mode for parameter changes.
ZERO (0)
Initiates a routine that zeros the power meter sensor combination.
CAL FACTOR (2)
The power meter enters the calibration factor entry mode and a cal factor printed on the sensor can be entered.
MNL FILTER (8)
Numeric entry mode becomes active and the user can now enter a new filter for the selected channel. Filter numbers range from zero through nine.
A (A-B)
Selects channel A as the single sensor active channel and initiates the command to put the meter in the display channel A power mode.
CAL ADJ (1)
The power meter enters the calibration mode and a reference calibration factor can be entered prior to being calibrated to the 1 mW power reference.
OFFSET (3)
Enters the offset entry mode and the user can enter an offset for the channel selected. The range of offsets is -99.99 to +199.99 dB in 0.01 db increments.
STORE (4)
Enters the store instrument state numeric entry mode becomes active and the user can enter a storage register location in the range of one to nineteen.
B (B-A)
Selects channel B as the single sensor active channel and initiates the command to put the meter in the display channel B power mode.
REL (DSP → OFS)
The rel (relative) mode is enabled and power levels relative to some other power level is measured.
B/A (A/B)
Sets the power meter to the double sensor mode and initiates the command to display the ratio of the power readings. The active entry channel is B and the ratio order is B/A.
↑ dBm WATT ↓ (ENTER)
This command toggles the measurement units depending on the user wanting a linear or logarithmic display.
SHIFT
Enables a shifted function of the A, B, and B/A keys. This allows for ratio (A/B) and the difference of two power levels to be measured.
LCL (CLEAR ENTRY)
Returns the power meter to the local mode if not in local lockout from a bus command.
LINE
Primary power to the meter is switched on and off.
In places where key cap labels are followed by letters or symbols in parentheses the keys have a secondary function to the one in the simplified explanation. When the data entry mode is active the keys are SET A for + and – signs, SET B for the decimal point, various keys for numeric inputs 0 through 9, REL where a calculated offset is displayed DSP → OFS, ↑ dBm WATT ↓ when information in the display is entered ENTER, and LCL for cancelling the entry mode CLEAR ENTRY.
⚠ A and B
The inputs to channel A and B are through female 12 contact audio connectors.
RECALL (9)
Information in storage register locations zero through nineteen can be recalled and displayed.
OSC
Turns the power reference oscillator on and off. When Option 002 is installed this key turns both reference oscillators on and off.
AUTO RANGE (5)
Causes the selected channel to enter an auto range mode.
POWER REF
The power reference output is a 50 ohm type N connector and the signal is 1 mW at 50 MHz used for calibrating the sensor meter combination.
PRESET
The power meter is put into a preset state and the parameters for channel A and B are set to default conditions.
MNL RANGE (6)
The numeric entry mode becomes active and the user can enter a power range of one through five.
AUTO FILTER (7)
The selected channel enters the auto filter mode and one of nine filters is automatically selected.

Figure 3-1. Simplified Front Panel Features

SIMPLIFIED OPERATION

PRESET

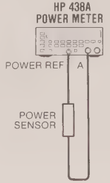
Press PRESET to set the Power Meter to the following conditions:

- Measurement Mode = Sensor A
- Reference Oscillator = Off
- Active Entry Channel = A
- Measurement Units = Watts
- REL Mode = Off
- Measurement Parameters (set for Sensor A and Sensor B)
  - Cal Factor = 100.0%
  - Cal Adj = 100.0%
  - Offset = 0.00 dB
  - Auto Filter
  - Auto Range

In addition, default conditions are set for some remote-only functions. Refer to Table 3-5, Response to a Clear Message (and PRESET).

CALIBRATION

Connect the power sensor to the Power Meter as shown.



Press ZERO to zero the Power Meter. Each sensor must be zeroed separately for dual sensor operation.

CAL ADJ is used only during calibration for entering the sensor's calibration factor at 50 MHz (that is, the reference calibration factor). For example, to calibrate the Power Meter to the sensor with a reference cal factor of 98%, press

CAL ADJ, RECALL 9, MNL FILTER, ENTER ↑dBm WATT↓ 8

MEASUREMENT MODES

The Power Meter can display single sensor (A or B), dual sensor ratio (A/B or B/A) or dual sensor difference (A–B or B–A) power measurements. In addition, measurements can be displayed relative to a reference measurement.

SENSOR

To display the Sensor A power measurement on the front panel, press A.

Single sensor measurements are displayed in dBm or Watts.

To display the ratio of Sensor A divided by Sensor B, press SHIFT, A/B B/A.

Ratio measurements are displayed in dB or %.

To display the difference between Sensor A and Sensor B, press SHIFT, A-B A.

Difference measurements are displayed in dBm or Watts.

REL

Press REL to enter and exit relative mode.

Once relative mode has been entered, the first power reading is saved as a reference. Successive measurements are displayed relative to the reference.

The REL annunciator in the front panel display lights when the Power Meter is in relative mode.

MEASUREMENT PARAMETERS

Measurement parameters can be set for each sensor. Blue keys indicate parameters that have selectable values. Values are selected in a Blue Key – Data – ENTER format. Data consists of digits 0 through 9, ±, and the decimal point. Pressing any blue key activates the data functions of the corresponding keys.

SET A and SET B

SET A and SET B allow measurement parameters to be entered for Sensor A and Sensor B. For example, to designate channel A as the active entry channel, press SET A/B.

Any measurement parameters that are entered will apply to Sensor A only, regardless of the measurement mode displayed on the front panel.

CAL FACTOR

The calibration factor is the frequency response of the sensor relative to 50 MHz. For example, to enter a calibration factor of 100%, press

CAL FACTOR, 1, 0, 0, ENTER ↑dBm WATT↓

MEASUREMENT PARAMETERS (cont'd)

Filter

A digital filter averages measurement readings to reduce jitter. A filter number (0 through 9) is entered to set the filter length. The filter length is the number of readings averaged and is equal to 2 to the power of the filter number (that is, from 1 to 512 in powers of 2).

[AUTO FILTER] selects the optimum filter length automatically.

Because of speed, resolution, and display considerations, the filter can be set manually. Measurements with higher filter numbers are slower and more settled; measurements with lower filter numbers are faster and have more jitter. For example, to manually set the filter to 7 (filter length of 128), press

[MNL FILTER] [AUTO FILTER] 7 [ENTER dBm WATT]

Range

The Power Meter divides the sensor's power range into five ranges of 10 dB each. Range 5 may be less than 10 dB if the sensor has a power range of less than 50 dB. Range 1 is the most sensitive, and range 5 is the least sensitive.

[AUTO RANGE] sets the correct range automatically for the current measurement.

Manual range is used primarily with the rear panel recorder output or when faster readings are required. For example, to set range manually to Range 3, press

[MNL RANGE] [OFFSET] 3 [ENTER dBm WATT]

Offset

Offsets can be added to measurements to compensate for gain or loss in the measurement system. For example, to add an offset of 20 dB, press

[OFFSET] [CAL FACTOR] 2 0 [ZERO] [ENTER dBm WATT]

MEASUREMENT UNITS

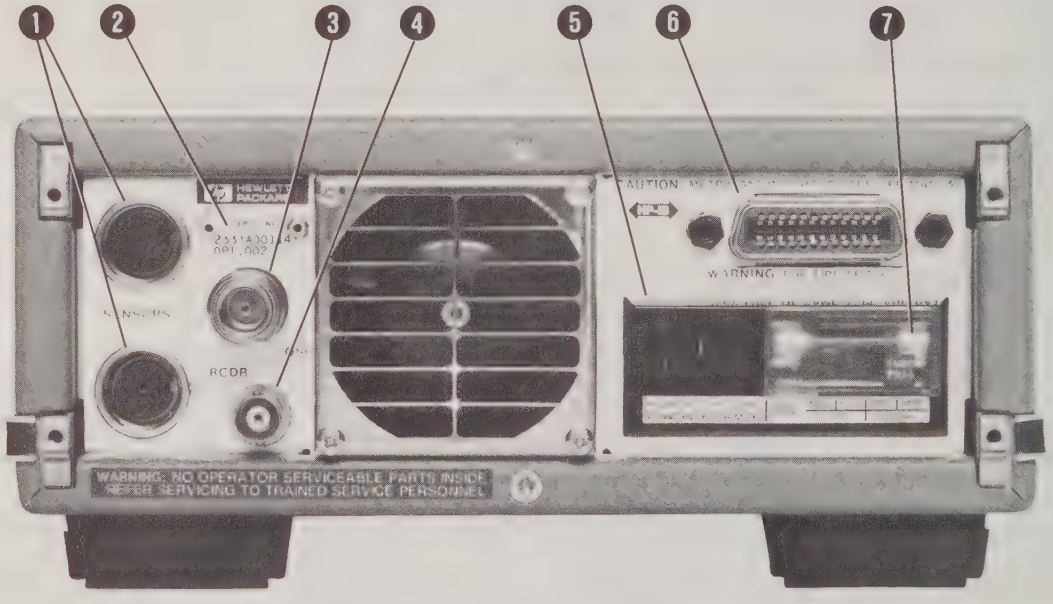
Single sensor and difference measurements are displayed in units of Watts or dBm. Ratio and relative measurements are displayed in either percent of dB. Press [dBm WATT] to toggle from one measurement unit to another.

STORE and RECALL

The Power Meter can store up to 19 instrument configurations for recall at a later time. For example, to store an instrument configuration in storage register 10, press

[STORE] [CAL ADJ] 1 0 [ZERO] [ENTER dBm WATT]

[RECALL] [OFFSET] 3 [ENTER dBm WATT] recalls an instrument configuration stored in register 3 and changes the Power Meter to the recalled parameters.



1 SENSORS A B

Option 002 rear panel inputs to channel A and B are through 12 contact female audio connectors. Inputs are in parallel with front panel channel A and B.

2 Serial Number Plate

First four digits and letter constitute the prefix which defines the instrument configuration. The last five digits form a sequential suffix that is unique to each instrument. The plate also indicates any options supplied with the instrument.

3 OSC

Option 002 rear panel 1 mW power reference output from the added oscillator. Output connector is a 50 ohm type N.

4 RCDR

BNC connector with an analog 0 to 1 volt signal that is related to power level measured by the meter. Output impedance is 1k ohm.

5 Line Power Module

Permits operation from 100, 120, 220, or 240 Vac. The number visible in the window indicates nominal line voltage to which the instrument must be connected. The center conductor is safety earth ground.

6 HP-IB Connector

Female connector with 24 contacts used to connect the power meter to Hewlett-Packard Interface Bus (HP-IB) for remote operation.

7 Fuse

1.0A 250V for 100/120 Vac operation and 500 mA 250V for 220/240 Vac operation. Ordering information is presented in Section II, Installation.

Figure 3-2. Rear Panel Features

TURN-ON INSTRUCTIONS (cont'd)

CAUTION

Before the instrument is switched on, it must be set to the voltage of the power source or damage to the instrument may result.

3-8. Turn-On

Turn-On Procedure. If the Power Meter is already plugged in, press the LINE switch to ON.

If the power cable is not plugged in, follow these instructions.

On the rear panel:

1. Check the line voltage switch for correct voltage selection.

2. Check that the fuse rating is appropriate for the line voltage used (see Figure 2-1). Fuse ratings are printed on the rear panel.

3. Plug in the power cable.

On the front panel, press the LINE switch to ON.

NOTE

Turn-On Configuration. *The Power Meter turns on to the same control settings it had before line power was removed. An exception to this is that it always turns on in the local mode. In addition some HP-IB default conditions are enabled. Refer to "Turn on Default Conditions" later in this section.*

When the Power Meter is turned on, it will execute a power up sequence which will be followed by an automatic RECALL 0. The power up sequence will run some self test routines to verify the operation of ROM, RAM, and display circuits. If any self test failures occur an error message will be reported to the user on the front panel display. If, for some reason, RAM content was lost this error will be reported and all storage registers initialized to put the Power Meter into the PRESET state. Storage location 0 is also set to the PRESET state when a RAM error occurs. This means the Power Meter will be in the PRESET state when it begins operation. The internal HP-IB address switch is read only when the memory content is lost. In all other cases the HP-IB address that is entered from the front panel is the one saved in RAM.

NOTE

An internal battery is used to retain data in RAM during off periods. The data restores the last control setup that was saved in storage location zero and the other nineteen storage registers.

3-9. Error Messages

Power up error message numbers as well as other error messages displayed on the front panel are listed and explained in Table 3-8 Error Messages. As an example, if a ROM or RAM failure occurs, the Power Meter will display an error code number in the range of 61 through 66 depending on the location in memory that has a problem.

3-10. Power Reference and Calibration

A POWER REF of 1.00 mW at 50 MHz is available at the front panel for calibrating the Power Meter to the sensor. The Power Meter to sensor calibration is accomplished by connecting the sensor to the POWER REF output. Press the ZERO key, (wait for the zeroing routine to finish). Press the CAL ADJ key (wait for the cal adj routine to finish). Entering the rcf (reference calibration factor) in percent, and pressing the ENTER key. The internal power reference is a 1 mW (0 dBm) 50 MHz oscillator that is factory set to ± 0.7% and traceable to the National Bureau of Standards.

3-11. OPERATOR'S CHECKS

Operator's checks are simple procedures designed to verify that the main functions of the Power Meter operate properly. Two procedures are provided, one for basic (front panel) checks and the other for HP-IB message checks.

OPERATOR'S CHECKS

3-12. Basic Functional Checks

Description The functions of the Power Meter are checked using power sensors, sensor cables, and a power splitter. These checks provide reasonable assurance that most of the front panel controlled functions are being executed by the Power Meter.

Equipment

Power Sensors (2)	HP 8480 Series
Sensor Cables (2)	HP 11730 Series
Power Splitter	HP 11667A
Adapter N(m) to N(m)	HP 1250-1528
Adapter APC-3.5(f) to N(m)	HP 1250-1744

Procedure

1. The following procedure was developed using power sensors HP 8485A and HP 8481A. Using other sensors such as the HP 8481B will result in different displays. Turn on the Power Meter and observe the power up routine with nothing connected to the inputs. During power up the diagnostics stored in ROM are executed under microprocessor control and enable the display to flash all segments of the LED's, all letters, and all symbols. This is followed by a shorter flash of all dashes, before the final display of no CH A or B, WATT A or B, Error 31 or 32, and flashing A or B. Since the Power Meter stores the last active parameters in storage location 0 this stored information is what will be recalled and displayed during power up. This is the reason for the "A" or "B" information being displayed.

2. Verify that the power up internal diagnostics are exercised without any error messages other than no CH A, ERROR 31 or no CH B, ERROR 32 depending on which channel was active during power down.

3. Press PRESET. This sets the parameters for channel A and B to:
   Cal Factor = 100.0%
   Offset = 0.00 dB
   Low Limit = 0.00 dB
   High Limit = 0.00 dB
   Auto Filter
   Auto Range
   and the Power Meter is set to the following conditions:
   Measurement Mode = Sensor A
   Reference Oscillator is OFF
   Active Entry Channel = A
   Measurement Units = Watt
   Limits Checking is OFF
   Rel Mode is OFF
   Group Execute Trigger Mode = Trigger with Delay (GT2)
   Trigger Mode = Free Run

4. Connect a power sensor with associated cable to channel A input as shown in Figure 3-3. Error message should disappear and display will either show some power level, or PLEASE 0, and Error 15. Annunciators WATT A, 100 % CF, and A on.

5. Connect power sensor to 1 mW POWER REF. Display shows some power level.

OPERATOR'S CHECKS

Basic Functional Checks (cont'd)

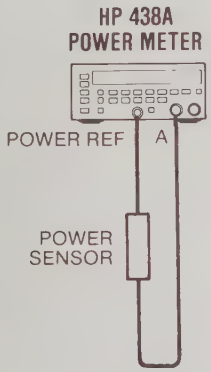


Figure 3-3. Front Panel Checks Setup (1)

Procedure cont'd

6. Press ZERO. Wait approximately 15 seconds for the zeroing routine to finish. Verify that display shows — — — — , with walking decimal point. Observe that the POWER REF OSC LED is off during this routine.

7. Press CAL ADJ. Display shows Ent — — — — , and annunciators %, 100.0 % CF A, and rcF are on. Enter REF CAL FACTOR shown on power sensor using blue numeric keys and the SET B key for a decimal point. Then press ENTER. Display will show — — — — , with a walking decimal point and annunciators A, A. Wait approximately 5 seconds for the CAL ADJ routine. Observe that during CAL ADJ the POWER REF OSC LED will be turned off and on.

8. Press CAL FACTOR. Display shows Ent — — — — , %, 100.0 % CF A, and 1-150. Enter reference cal factor. If the CF is the same as the one entered in the preceding step just press ENTER and the CF displayed will be the one used in the measurements.

9. Display will now show 1.000 -3, with annunciators WATT, A, 100.0 % CF, and A on.

10. Press dBm WATT. Display shows a change to 0.00 dBm.

11. Press B and repeat steps 4 through 10 for channel B inputs.

12. Remove sensor from POWER REF OSC and connect the equipment as shown in Figure 3-4.

13. Display shows some power level. Annunciators WATT B, 100.0 % CF and B are on.

14. Press dBm WATT to display dBm. Display will now show the loss through the power splitter. This number will be used as an offset to get the power level displayed back to 1 mW. Annunciators B, MNL, 100.0 % CF, and B are on.

15. Press OFFSET. Display shows Ent — — — — , annunciators show dB, 0.00 B, and $\leq$ 99.99. Key in a number equivalent to power loss through power splitter using blue keys representing the numbers and the SET B key for the decimal point then press ENTER. An alternative is to just press REL key which is DSP to OFS in the blue key mode. This takes the loss in dB through the splitter and uses it as the offset to return to a display of 1 mW.

OPERATOR'S CHECKS

Basic Functional Checks (cont'd)

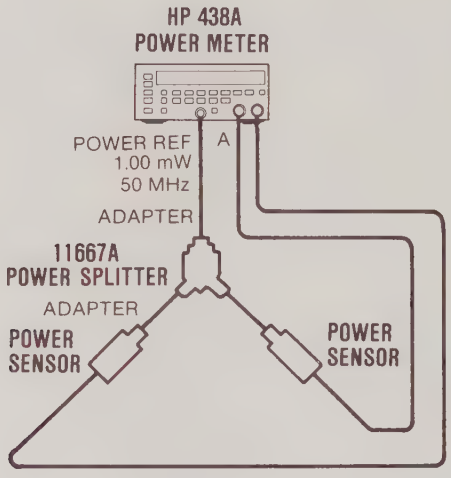


Figure 3-4. Front Panel Checks Setup (2)

16. Press A to return to channel A as the active channel. Repeat step 15 for channel A.

17. Press B/A, press dBm WATT to display ratio in %.

18. The above checks have been using the AUTO RANGE and AUTO FILTER mode. To check the two MNL (manual) keys for RANGE and FILTER press MNL RANGE and the display will show Ent - . Annunciators rng 3, 1-5, and A will be on for channel A. Annunciators rng 1, 1-5, and B will be on for channel B. Press MNL FILTER and the display will show Ent - . Annunciators FLt 1, 0-9, and A will be on for channel A. Annunciators FLt 7, 0-9, and B will be on for channel B. Observe the rng and FLt number difference because of the sensor being used.

19. Note: several combinations of keys can be exercised at this time to further familiarize yourself with the front panel operation.

OPERATOR'S CHECKS

3-13. HP-IB Functional Checks

Description

These procedures check the Power Meter's ability to process or send the HP-IB messages described in Table 3-3. Only the Power Meter, a power sensor, a controller, and an HP-IB interface are needed to perform these checks.

These procedures do not check that all the Power Meter program codes are being properly interpreted and executed by the instrument. However, if the power-up sequence and front panel operation are good, the program codes, in all likelihood, will be correctly implemented.

The validity of these checks is based on the following assumptions:

a. The Power Meter performs properly when operated via the front panel keys (that is, in local mode). This can be verified by the Basic Functional Checks in this section.

b. The bus controller properly executes HP-IB operations.

c. The bus controller's interface properly executes the HP-IB operations.

If the Power Meter appears to fail any of these HP-IB checks, the validity of the above assumptions should be confirmed before attempting to service the instrument.

The select code of the controller's HP-IB interface is assumed to be 7. The address of the Power Meter is assumed to be 13 (its address set at the factory). This particular select code-address combination (that is, 713) is not necessary for these checks to be valid. However, the program lines presented here must be modified for any other combination.

These checks can be performed together or separately. Any special requirements for a check are described at the beginning of the check.

Initial Setup

The test setup is the same for all of the checks. Connect the equipment as shown in Figure 3-5.

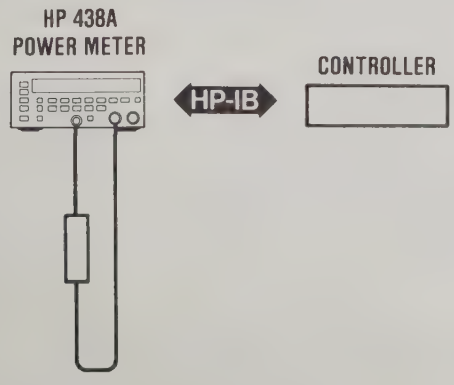


Figure 3-5. HP-IB Functional Checks Setup

OPERATOR'S CHECKS

HP-IB Functional Checks (cont'd)

Equipment

HP-IB Controller	.....	HP-85B/82936A (ROM Drawer)/ 00085-15005 (Advanced Programming ROM)
—or —		HP 9826A Option 011 (BASIC 2.0 ROM based system)
HP-IB Interface	.....	HP 82937A (HP-85B only)
Power Sensor	.....	HP 848x series

Remote and Local Messages and LCL Key

Note This check determines whether or not the Power Meter properly switches from local to remote control, from remote to local control, and whether or not the LCL key returns the instrument to local control. Before beginning this check, set the LINE switch to OFF, then to ON.

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Send the Remote message (by setting the Remote Enable bus control line, REN, true and addressing the Power Meter to listen).	REMOTE 713	REMOTE 713

Operator's Response Check that the Power Meter's RMT and LSN annunciators are on.

Send the Local message to the Power Meter	LOCAL 713	LOCAL 713

Operator's Response Check that the Power Meter's RMT annunciator is off but its LSN annunciator is on.

Send the Remote message to the Power Meter.	REMOTE 713	REMOTE 713

Operator's Response Check that both the RMT and LSN annunciators are on. Press the LCL key on the Power Meter. Check that the RMT annunciator is now off, but that the LSN annunciator remains on.

Sending the Data Message

Note This check determines whether or not the Power Meter properly issues Data messages when addressed to talk. Before beginning this check, set the Power Meter's LINE switch to OFF, then to ON. Press PRESET and set the manual filter to 9. (If an HP 9826A controller is used, a short program is required to perform this check.)

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Address the Power Meter to talk and store its output in variable V.	ENTER 713;V	10 V=0 20 ENTER 713;V
Display the value of V.	DISP V	30 DISP V 40 END

OPERATOR'S CHECKS

HP-IB Functional Checks (cont'd)

Operator's Response

Check that the Power Meter's TLK annunciator is on. The controller should display the same value as the one shown in the Power Meter's display. (Note that the Power Meter displays data using engineering notation. The controller may display the same value using a different format.)

Receiving the Data Message

Note

This check determines whether or not the Power Meter properly receives Data messages.

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Send the first part of the Remote message (enabling the Power Meter to remote).	REMOTE 7	REMOTE 7
Address the Power Meter to listen (completing the Remote message), then send a Data message.	OUTPUT 713; "KB 95 EN"	OUTPUT 713; "KB 95 EN"

Operator's Response

Check that the Power Meter's RMT and LSN annunciators are on and that its display indicates the channel A cal factor is set to 95%.

Local Lockout and Clear Lockout/Set Local Messages

Note

This check determines whether or not the Power Meter properly receives the Local Lockout message, disabling all front panel keys (including LCL). This check also determines whether or not the Clear Lockout/Set Local message is properly received and executed by the Power Meter. This check assumes the Power Meter is in remote mode.

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Send the Local Lockout message.	LOCAL LOCKOUT 7	LOCAL LOCKOUT 7

Operator's Response

Check that the RMT annunciator is on. Press the Power Meter's LCL key. The RMT annunciator should remain on.

Send the Clear Lockout/Set Local message.	LOCAL 7	LOCAL 7

Operator's Response

Check that the Power Meter's RMT annunciator is off.

OPERATOR'S CHECKS

HP-IB Functional Checks (cont'd)

Return the Power Meter to remote mode if the remaining checks in this section are to be performed.	REMOTE 713	REMOTE 713

Operator's Response Check that the Power Meter's RMT annunciator is on.

Clear Message

Note This check determines whether or not the Power Meter properly responds to the Clear message. This check assumes that the Power Meter is in remote mode.

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Send a Data message to set to the cal factor to 98.5%.	OUTPUT 713; "KB 98.5 EN"	OUTPUT 713; "KB 98.5 EN"

Operator's Response Check that the Power Meter's display indicates the channel A cal factor is set to 98.5%.

Send the Clear message (setting the cal factor to 100%).	CLEAR 713	CLEAR 713

Operator's Response Check that the Power Meter's display indicates the channel A cal factor is set to 100%.

Abort Message

Note This check determines whether or not the Power Meter becomes unaddressed when it receives the Abort message. This check assumes the Power Meter is in remote mode.

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Address the Power Meter to listen.	OUTPUT 713	OUTPUT 713

Operator's Response Check that the Power Meter's LSN annunciator is on.

Send the Abort message, unaddressing the Power Meter from listening.	ABORTIO 7	ABORT 7

Operator's Response Check that the Power Meter's LSN annunciator is off.

Status Byte Message

Note This check determines whether or not the Power Meter sends the Status Byte message. Before beginning this check, set the Power Meter's LINE switch to OFF then to ON and press PRESET.

OPERATOR'S CHECKS

HP-IB Functional Checks (cont'd)

Status Byte Message

Note This check determines whether or not the Power Meter sends the Status Byte message. Before beginning this check, set the Power Meter's LINE switch to OFF then to ON and press PRESET.

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Place the Power Meter in serial-poll mode (causing it to send the Status Byte message).	SPOLL(713)	SPOLL(713)

Operator's Response Check that the controller's display reads 0.

Require Service Message

Note This check determines whether or not the Power Meter can issue the Require Service message (set the SRQ bus control line true). This check can be performed in either local or remote mode.

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Send a Data message to set the Service Request Mask to 4.	OUTPUT 713 USING "2A,B"; "@1",4	OUTPUT 713 USING "2A,B"; "@1",4
Send a Data message containing an entry error. This causes the Require Service message to be sent.	OUTPUT 713; "RM 15 EN"	OUTPUT 713; "RM 15 EN"

Operator's Response Check that the Power Meter's SRQ annunciator is on. (If an HP 9826A controller is being used, a short program is required to perform the next portion of this check.)

Read the binary status of the controller's HP-IB interface and store the data in variable V (in this step, 7 is the interface's select code, and 2 (HP-85B) and 7 (HP 9826A) are status registers for bus control lines).	STATUS 7, 2; V	10V=0 20 STATUS 7,7;V
Display the value of the SRQ bit (in this step, 6 (HP-85B) and 10 (HP 9826A) are the SRQ bits for the controller, numbered from 0).	DISP "SRQ="; BIT(V,6)	30 DISP "SRQ =";BIT(V,10) 40 END

Operator's Response Check that the SRQ value is 1, indicating that the Power Meter issued the Require Service message.

OPERATOR'S CHECKS

HP-IB Functional Checks (cont'd)

Status Bit Message

Note

This check determines whether or not the Power Meter sends the Status Bit message. This check can be performed in either local or remote mode. If the Power Meters's SRQ annunciator is off, perform the first part of the Require Service Message check before beginning this check.

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Configure the Power Meter to respond to a parallel poll with positive-true logic on HP-IB data line DIO3.	SEND 7;LISTEN 19 CMD 5 SCG 10	PPOLL CONFIGURE 713; 10
Place the Power Meter in parallel poll mode (causing it to send the Status Bit message).	PPOLL(7)	PPOLL(7)

Operator's Response

Check that the SRQ annunciator is on and that the response to the parallel poll is 4, indicating that the Power Meter issued the Status Bit message.

Unconfigure the Power Meter from responding to a parallel poll.	SEND 7; LISTEN 19 CMD 5 SCG 18	PPOLL UNCONFIGURE 713
Place the Power Meter in parallel poll mode.	PPOLL(7)	PPOLL(7)

Operator's Response

Check that the SRQ annunciator is on and that the response to the parallel poll is 0, indicating that the Power Meter is no longer configured to respond to a parallel poll. Set the LINE switch to OFF, then to ON, to turn off the SRQ annunciator.

Trigger Message

Note

This check determines whether or not the Power Meter responds to a Trigger message. This check assumes that the Power Meter is in remote mode. (If an HP 9826A is used as the controller, a short program is required to perform this check.)

Description	HP-85B (BASIC)	HP 9826A(BASIC)
Send a Data message to place the Power Meter in the Trigger Hold mode.	OUTPUT 713; "TR0"	10 OUTPUT 713; "TR0"
Send the Trigger message.	TRIGGER 713	20 TRIGGER 713
Address the Power Meter to talk and store the data in variable V.	ENTER 713;V	30 V=0 40 ENTER 713;V
Display the value of V.	DISP V	50 DISP V 60 END

Operator's Response

Check that the Power Meter's RMT and TLK annunciators are on and that the controller displays the same value as the one shown in the Power Meter's display. (Note that the Power Meter displays data using engineering notation. The controller may display the same value using a different format.)

Table 3-3. Message Reference Table (1 of 2)

HP-IB Message	Applicable	Response	Related Commands and Controls	Interface Functions[1]
Data	Yes	All Power Meter operations, (except setting the LINE switch and setting the HP-IB address) and remote-only functions are bus programmable. All measurement results are available to the bus.		AH1, SH1, T5, TE0, L4, LE0
Trigger	Yes	The Power Meter's response to bus command GET (Group Execute Trigger) can be programmed. The default condition is trigger with Delay (GT2). If in remote and addressed to listen, the Power Meter makes a measurement according to previously programmed setup.	GET	DT1
Clear	Yes	The Power Meter is set to the same conditions as established by PRESET. Refer to Table 3-5.	DCL, SDC	DC1
Remote	Yes	Remote mode is enabled when the REN bus control line is true. Remote mode is not entered, however, until the first time the Power Meter is addressed to listen. The front panel RMT annunciator lights when the intrument is actually in remote mode. When entering remote mode, no instrument settings or functions are changed but all front panel keys, except LCL, are disabled.	REN	RL1
Local	Yes	The Power Meter returns to local mode (front panel control). It responds equally to the Go To Local (GTL) bus command and the front panel LCL key.	GTL	RL1
Local Lockout	Yes	Disables all front panel keys, including LCL. Only the controller can return the Power Meter to local (front panel control).	LLO	RL1
Clear Lockout/ Set Local	Yes	The Power Meter returns to local mode (front panel control) and local lockout is cleared when the REN bus control line goes false.	$\overline{\text{REN}}$	RL1
Pass Control/ Take Control	No	The Power Meter has no controller capability.		C0
Require Service	Yes	The Power Meter sets the SRQ bus control line true if one of the following conditions exists and has been enabled (via the Service Request Mask) to send the message for that condition: data ready, cal/zero completed, entry error, measurement error, or over/under limits.	SRQ	SR1

[1]Commands, control lines, and interface functions are defined in IEEE Std 488-1978. Knowledge of these may not be necessary if your controller's manual describes programming in terms of the twelve HP-IB Messages shown in the left column.

Table 3-3. Message Reference Table (2 of 2)

HP-IB Message	Applicable	Response	Related Commands and Controls	Interface Functions[1]
Status Byte	Yes	The Power Meter responds to a Serial Poll Enable (SPE) bus command by sending an 8-bit byte when addressed to talk. If the instrument is holding the SRQ bus control line true (issuing the Require Service message), bit position 7 in the Status Byte and the bit representing the condition causing the Require Service message to be issued will both be true. The bits in the Status Byte are latched but can be cleared by removing the causing condition and then reading the Status Byte or by receiving the Clear Status (CS) program code.	SPE, SPD	T5
Status Bit	Yes	The Power Meter responds to a Parallel Poll Enable (PPE) bus command by sending a bit on a controller selected HP-IB data line.	PPE, PPD, PPC, PPU	PP1
Abort	Yes	The Power Meter stops talking and listening.	IFC	T5, TE0, L4, LE0

[1]Commands, control lines, and interface functions are defined in IEEE Std 488-1978. Knowledge of these may not be necessary if your controller's manual describes programming in terms of the twelve HP-IB Messages shown in the left column.

Complete HP-IB capability as defined in IEEE Std 488-1978 and ANSI Std MC1.1 is SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP1, DC1, DT1, and C0

3-14. REMOTE OPERATION, HEWLETT-PACKARD INTERFACE BUS

The Power Meter can be operated through the Hewlett-Packard Interface Bus (HP-IB). HP-IB is Hewlett-Packard's implementation of IEEE Standard 488 and the identical ANSI Standard MC1.1. Bus compatibility, programming, and data formats are described in the following paragraphs.

All front panel functions (except that of the LINE switch and HP-IB address entry) are programmable via HP-IB. The SHIFT key is not programmable because the shifted functions have their own program codes. Additional functions are available in remote operation only.

A quick test of the Power Meter's HP-IB interface is described in this section under HP-IB Functional Checks. These checks verify that the Power Meter can respond to or send each of the applicable bus messages described in Table 3-3. For more information about HP-IB, refer to IEEE Standard 488 (or the identical ANSI Standard MC1.1), the Hewlett-Packard Electronic Systems and Instruments catalog, and the booklet "Improving Measurements in Engineering and Manufacturing" (HP part number 5952-0058).

3-15. HP-IB Compatibility

The Power Meter's complete bus compatibility as defined by IEEE Standard 488 (and the identical ANSI Standard MC1.1) is described at the end of Table 3-3. Table 3-3 also summarizes the Power Meter's HP-IB capabilities in terms of the twelve messages in the "HP-IB Message" column.

3-16. Remote Mode

Remote Capability. The Power Meter communicates on the bus in both remote and local modes. In remote, most of the Power Meter's front panel keys are disabled (exceptions are the LINE switch and the LCL key). Front panel displays, however, remain active and valid. In remote, the Power Meter can be addressed to talk or listen. When addressed to listen, the Power Meter responds to the Data, Trigger, Clear (SDC), Remote, and Local messages. When addressed to talk, the Power Meter can issue the Data and Status Byte messages. Whether addressed or not, the Power Meter responds to the Clear (DCL), Local Lockout, Clear Lockout/Set Local, and Abort messages. In addition, the Power Meter may issue the Require Service and Status Bit messages.

Local-to-Remote Changes. The Power Meter switches to remote operation upon receipt of the Remote message. The Remote message has two parts:

a. remote enable bus control line (REN) set true, and

b. device listen address received once (while REN is true).

When the Power Meter switches to remote, the front panel RMT annunciator turns on. The Power Meter's control settings remain unchanged with the local-to-remote transition.

3-17. Local Mode

Local Capability. In local, the Power Meter's front panel controls are fully operational and the instrument will respond to the Remote message. Whether it is addressed or not, it will also respond to the Clear, Local Lockout, Clear Lockout/Set Local, and Abort messages. When addressed to talk, the instrument can issue Data messages and the Status Byte message. Whether addressed or not, the instrument can issue the Require Service and Status Bit messages.

Remote-to-Local Mode Changes. The Power Meter always switches to local from remote whenever it receives the Local message (GTL) or the Clear Lockout/Set Local message. (The Clear Lockout/Set Local message sets the remote enable bus control line [REN] false.) If not in Local Lockout mode, the Power Meter switches to local from remote whenever the front panel LCL key is pressed.

Local Lockout. A local lockout is recommended for purely automatic applications. Local lockout disables the LCL key and allows return-to-local only under program control.

NOTE

Return-to-local can also be accomplished by setting the Power Meter's LINE switch to OFF, then to ON. However, this technique has some disadvantages:

a. It defeats the purpose and advantage of local lockout (that is, the system controller loses control of a system element).

b. There are several HP-IB conditions that reset to default states at turn-on.

3-18. Addressing

The Power Meter interprets the byte on the eight HP-IB data lines as an address or a bus command if the bus is in the command mode. The command mode is defined as attention control line (ATN) true and interface clear control line (IFC) false. Whenever the Power Meter is addressed (whether in local or remote), either the TLK or LSN annunciator on the front panel turns on.

The Power Meter's HP-IB address is set in decimal from the front panel. HP-IB address switches (set in binary) are located inside the instrument. The only time the Power Meter reads the internal switches, however, is when the internal RAM contents storing the front panel address setting have been lost (for example, when the battery fails). Additional information for setting the internal switches is located in Sections II and VIII.

The Power Meter's HP-IB address can be set from the front panel as follows:

a. Set Power Meter's LINE switch from OFF to ON while pressing and holding the LCL key.

b. Release the LCL key.

c. Enter the desired HP-IB address in decimal (0-30) and then press the ENTER key.

To display the current HP-IB address setting in the front panel display, press and hold the LCL key.

Listen Only Mode. The Power Meter is placed in Listen Only mode when its HP-IB address is set to 40. The Listen Only mode is provided to allow the Power Meter to accept programming from devices other than controllers.

Talk Only Mode. The Power Meter is placed in Talk Only mode when its HP-IB address is set to 50. In this mode, the instrument is configured to send Data messages whenever the bus is in the data mode (attention control line [ATN] false).

3-19. Turn-on Default Conditions

Several HP-IB parameters are reset at turn-on. The parameters and their default conditions are listed below.

- HP-IB Local Mode
- Unaddressed
- Service Request Mask cleared
- Status Byte cleared
- Free Run Trigger Mode
- GT2 (Trigger with Delay) response to Trigger message
- Parallel Poll data line unassigned
- Display Enable active

3-20. Data Messages

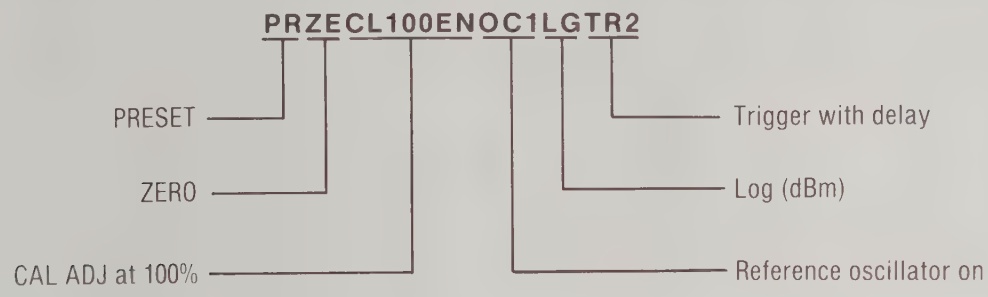
The Power Meter communicates on the interface bus primarily with Data messages. Data messages consist of one or more bytes sent over the bus' data lines when the bus is in the data mode (ATN bus control line false). Unless it is set to Talk Only, the Power Meter receives Data messages when addressed to listen. Unless it is set to Listen Only, the Power Meter sends Data messages or the Status Byte message when addressed to talk. Virtually all instrument operations available in local mode can be performed in remote mode via Data messages. The only exceptions are changing the LINE switch and changing the HP-IB address. In addition, the Power Meter may be triggered via Data messages to make measurements at a particular time.

3-21. Receiving the Data Message

The Power Meter responds to Data messages when it is enabled to remote (REN bus control line true) and it is addressed to listen. The instrument remains addressed to listen until it receives its talk address, an Abort message, or a universal unlisten command.

Data Input Format. The Data message string, or program string, consists of a series of ASCII codes. Each code is typically equivalent to a front panel keystroke in local mode. Thus, for a given operation, the program string syntax in remote mode is the same as the keystroke sequence in local mode. Example 1 shows a typical program string.

EXAMPLE 1: Typical Program String



Program Codes. All of the HP-IB codes normally used by the operator to control the Power Meter are given in Table 3-7, HP-IB Code to Parameter Summary. All front panel keys except LCL/ CLEAR ENTRY and SHIFT have corresponding program codes. Lower case alpha characters are interchangeable with upper case characters. The number 0 and the letter O are not interchangeable.

Numeric data can be entered in fixed, floating point, or exponential format. All numeric entries must be terminated with the program code "EN" (this is equivalent to pressing the ENTER key in local mode).

Turning Off Functions. When operating in local mode, OSC (reference oscillator) and REL (relative mode) toggle on and off with successive keystrokes. In remote mode these functions do not toggle on and off. Instead, a specific program code is required to turn off each function. Use RL0 to turn off REL mode and OC0 to turn off the reference oscillator.

Hold Range. When the Power Meter is addressed to listen and receives program code RH (Range Hold), it switches from auto range to manual range using the current auto range value. If the Power Meter is already in manual range mode no action is taken. No range number is entered with this program code.

Hold Filter. When the Power Meter is addressed to listen and receives program code FH (Filter Hold), it switches from auto filter mode to manual filter mode using the current auto filter value. If the Power Meter is already in manual filter mode no action is taken. No filter number is entered with this program code.

Limits. The limits checking function allows the Power Meter to monitor the power present at each sensor and indicate when that power is outside preset limits. Enabling the limits checking function and setting limit values are available only via remote programming.

To set the the limits for a sensor, address the Power Meter to listen and then send a Data message consisting of program code LL (limit low) or LH (limit high), a numeric value, and program code EN (ENTER). The allowable range for limit values is −299.999 to +299.999. Values entered that are outside of this range cause the limit to be set to the minimum or maximum value as appropriate. Limit values are entered in dBm and converted automatically to Watts when necessary.

The limits checking function is enabled by program code LM1 and disabled by program code LM0. When the limits checking function is enabled, it uses the last values set for the high and low limits. PRESET (and the Clear message) sets both the high and low limits for Sensors A and B to 0.000 dBm and disables the limits checking function.

If the limits checking function is enabled and the input power exceeds the high limit or is less than the low limit, the condition is indicated on the front panel as well as over the bus. The out-of-limits condition is indicated on the front panel by the flashing A and/or B annunciator. The out-of-limits condition is indicated only for the sensor(s) used by the current measurement mode. The out-of-limits condition can be indicated over the bus by setting the Service Request Mask to enable an out-of-limits condition to issue the Require Service message. This condition can also be indicated by reading the Status Message.

Display Functions. The selection of display functions is available only via remote programming.

Receiving the Data Message (cont'd)

During local operation, the Power Meter display is enabled to indicate measurement results, error codes, entries in progress, and instrument status. In remote mode, two additional display functions are allowed: display disable and display all.

Display Enable (DE). This function is identical to local operation and is the function in effect when no other display function has been selected. This is the display function at turn-on. This condition is also established by PRESET and the Clear message.

Display Disable (DD). This function blanks out the front panel display. All readings over the bus remain valid. This function is cleared by sending another display function program code (DA or DE), by PRESET, or by the Power Meter receiving the Clear message.

Display All (DA). This function causes the Power Meter to turn on all front panel display LED segments. It is used to verify that all display segments are working properly. This function is cleared by sending another display function program code (DE or DD), by PRESET, or by the Power Meter receiving the Clear message. (At turn-on, all the display segments light momentarily before the display enable becomes active.)

Triggering Measurements with the Data Message. A feature that is only available via remote programming is the selection of free run, standby, or triggered operation of the Power Meter. During local operation the Power Meter is allowed to free run, outputting data to the display as each measurement is completed. In remote, three additional operating modes are allowed: hold, trigger immediate, and trigger with delay.

Hold (TR0). This mode is used to set up triggered measurements (initiated by program codes TR1, TR2, and the Trigger message). In trigger hold mode, internal settings can be altered by the instrument itself or by the user via the bus. The instrument, however, is inhibited from outputting any data to the front panel display or to the HP-IB except as follows. The instrument will issue the Status Byte message if serial polled.

The Power Meter leaves hold mode when it receives either the free run, trigger immediate, or trigger with delay program codes, or the Trigger message, or when it returns to local mode via the LCL key. Upon leaving hold, the front panel display is updated as the new measurement cycle begins. The Status Byte will be affected by the events that occur during the new measurement cycle.

Trigger Immediate (TR1). When the Power Meter receives the trigger immediate program code, it makes one measurement in the shortest possible time. The instrument then waits for the measurement results to be read. While waiting, the instrument can process most bus commands without losing the measurement results. However, if the instrument receives GET (Group Execute Trigger), a new measurement cycle will be executed. Once the measurement results are read onto the bus, the Power Meter reverts to the hold mode. Measurement results obtained via trigger immediate are normally valid only when the instrument is in a steady, settled state.

Trigger with Delay (TR2). Triggering with delay is identical to trigger immediate except the Power Meter inserts a settling-time delay before taking the requested measurement. This settling time is a function of the selected range and filter and is sufficient to produce valid, accurate measurement results.

Free Run (TR3). This mode is identical to local operation and is the mode of operation in effect when no other trigger mode has been selected. The measurement result data available to the bus is constantly being updated as rapidly as the Power Meter can make measurements. Entry into remote from local via the LCL key sets the Power Meter to the free run mode. (A local command from the controller does not return the Power Meter to free run mode.)

Program Order Considerations. Although program string syntax is virtually identical to keystroke order, some program order considerations need highlighting.

Trigger Immediate and Trigger with Delay. When either of the trigger program codes TR1 or TR2 is received by the Power Meter, a measurement is immediately initiated. Once the measurement is completed, some bus commands can be processed without aborting the measurement. However, any HP-IB program code sent to the Power Meter before the triggered measurment results have been completed will abort the trigger. Thus, trigger codes should always appear at the end of a program string, and the triggered measurement results must be completed before any additional program codes that affect measurement are sent.

3-21. Receiving the Data Message (cont'd)

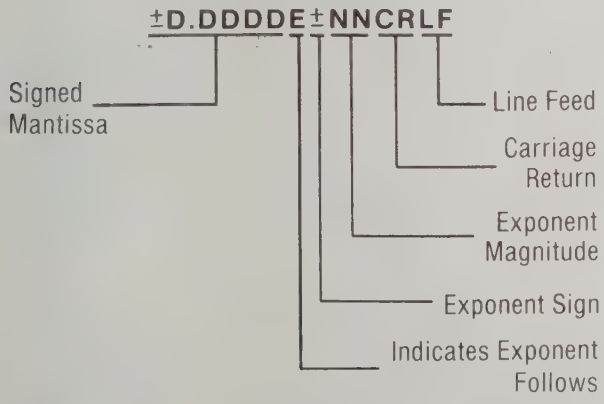
ZERO and CAL ADJUST. Zero the Power Meter before performing a calibration adjustment to avoid inaccurate measurement results.

OFFSET and Display Offset. The display offset program code (DO) is only valid when it immediately follows the program code for OFFSET (OS). When the Power Meter is addressed to listen and receives the program string "OS DO EN" (a Data message), the offset that causes the Power Meter display to read 0 dB or dBm, 1.000 mW, or 100% (depending on the measurement units and measurement mode) is entered.

3-22. Sending the Data Message

The Power Meter sends Data messages when addressed to talk. The instrument remains configured to talk until it is unaddressed to talk by the controller. To unaddress the Power Meter, the controller must send the Power Meter's listen address, a new talk address, an Abort message or a universal untalk command.

Data Output Format. As shown below, the output data is usually formatted as a real constant in exponential form: first the sign, then a digit, a decimal point, and four digits followed by the letter E and a signed power-of-ten multiplier. The string is terminated by a carriage return (CR) and line feed (LF). The Power Meter sends an EOI with the last byte of each output string.



When an error is output to the bus, it follows the same format described above. As long as the front panel display indicates an error condition, the Power Meter sends 9.0000E+40 as the measured data when addressed to talk. To determine the error code, it is necessary to read the Status Message. Refer to the Status Message paragraph below for additional information.

Exceptions to this format are the data output for the following functions:

Learn Mode #1

Learn Mode #2

Status Message

Identification

Service Request Mask Value

Each of these five functions is enabled by first addressing the Power Meter to listen. Then the Power Meter must receive a Data message with the appropriate program code. When the Power Meter is addressed to talk, it will output data for the selected function. The output format for these functions is described in the following paragraphs. Service Request Mask Value is explained later under Sending the Service Request Mask Value.

Learn Modes. In addition to being able to store front panel setups in its own registers, the Power Meter has two learn modes that use the controller's memory. One learn mode allows the Power Meter to send instrument configurations to the controller's memory. The second learn mode is a subset of the first and transfers only information that can be stored in a STORE/RECALL register.

Whenever data is being transferred between controller and Power Meter, it must do so in uninterrupted strings. If a data string is broken or interrupted, the data could be lost or offset, and misinterpreted by the Power Meter. An offset of data bytes can persist until EOI is read.

Learn Mode #1. After receiving an LP1 program code (Learn Mode #1) and when addressed to talk, the Power Meter sends a string of up to 128 ASCII characters containing information on the instrument configuration. The last character is sent with EOI bus line true, thus terminating the message. This data can then be stored in the controller's memory for future use.

When the Power Meter is addressed to listen, the ASCII data string can be returned to the Power Meter. The Power Meter changes accordingly.

Table 3-4 shows the information contained in the string and the order in which it is sent.

Table 3-4. Learn Mode #1 Output Format

Parameter	Output From Power Meter*
Trigger Mode	TRx
Measurement Mode	AP, BP, AR, BR, AD, or BD
Sensor A Parameters	AE
Cal Factor	KB xxx.x EN
Offset	OS sxx.xx EN
Range	RA or RM x EN
Filter	FA or FM x EN
Low Limit	LL sxxx.xxx EN
High Limit	LH sxxx.xxx EN
Sensor B Parameters	BE
Cal Factor	KB xxx.x EN
Offset	OS sxx.xx EN
Range	RA or RM x EN
Filter	FA or FM x EN
Low Limit	LL sxxx.xxx EN
High Limit	LH sxxx.xxx EN
Active Entry Channel	AE or BE
Measurement Units	LG or LN
Reference Oscillator Status	OC0 or OC1
Group Trigger Mode	GTx
Limits Checking Status	LM0 or LM1
EOI	Carriage Return Line Feed

* s indicates sign; x indicates a single digit

Learn Mode #2. After receiving the program code LP2 (Learn Mode #2) and when addressed to talk, the Power Meter sends 2 ASCII characters, @ and 2, followed by a string of 28 8-bit binary bytes. The last byte is sent with EOI bus line true, thus terminating the message. This binary data can then be stored in the controller's memory.

The most straight-forward way to program the system controller is to use a loop to read 30 binary characters and store them in an array. Learn Mode #2 requires a controller that can transfer information in binary form.

This string contains the following information:

Measurement mode
REL mode status (on or off)
Reference oscillator status (on or off)
Current reference value if in REL mode
Meausrement units (Log or Lin)
Cal Factor for each sensor
Offset for each sensor
Range for each sensor
Filter for each sensors

When the Power Meter is addressed to listen, the binary data can be returned to the Power Meter. The Power Meter changes accordingly.

Status Message. This function enables the Power Meter's current state to be read under program control. After receiving an SM program code (Status Message) and when addressed to talk, the Power Meter sends a string of 23 ASCII characters followed by carriage return (CR), line feed (LF), and EOI. The Status Message can be interpreted with the information shown in Figure 3-6.

Identification. This function is used to identify the the Power Meter's model number and the firmware version. After receiving program code ?ID and when addressed to talk, the Power Meter sends the following string: HP438A,VERX.XX. HP438A is the instrument model number and VERX.XX is the firmware version number.

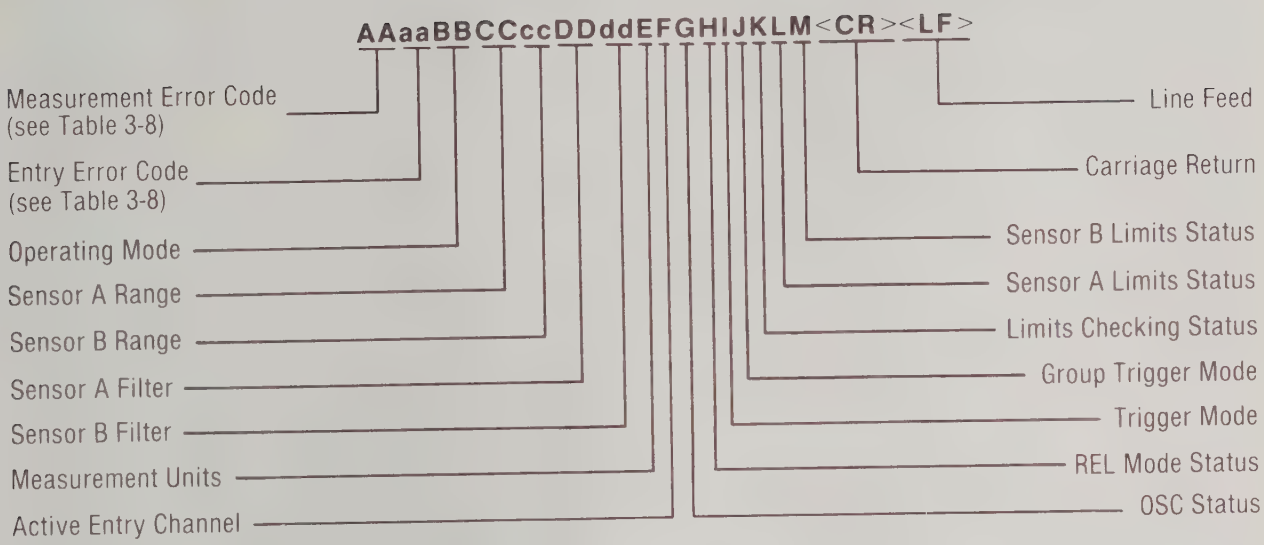
3-23. Receiving the Clear Message

The Power Meter responds to the Clear message by assuming the same conditions as established by PRESET. Refer to Table 3-5. The Power Meter responds equally to the Selected Device Clear (SDC) bus command when addressed to listen, and the Device Clear (DCL) bus command whether addressed or not.

3-24. Receiving the Trigger Message

When in remote and addressed to listen, the Power Meter responds to a Trigger message (the Group Execute Trigger bus command [GET]) by executing one of the pre-programmed codes shown in Table 3-6. If none of the codes has been preprogrammed (via a Data message), the Power Meter responds to the Trigger message by executing one settled-measurement cycle (GT2), which is the default condition at turn-on. Refer to Triggering Measurements with the Data Message, discussed earlier in this section.

Status Message Output Format



Codes Used in Status Message

BB	CC cc	DD dd	E	F	G	H	I	J	K	L M
Operating Mode	Range	Filter	Measure-ment Units	Active Entry Channel	OSC Status	REL Mode Status	Trigger Mode	Group Trigger Mode	Limits Checking Status	Sensor A & B Limits Status
00 Sensor A 01 Sensor B 02 A/B 03 B/A 04 A-B 05 B-A 06 Zeroing A 07 Zeroing B 08 Calib-rating A 09 Calib-rating B 10 Exter-nal Cal A 11 Exter-nal Cal B	Manual Range 01=1 02=2 03=3 04=4 05=5 Auto Range 11 1 12 2 13 3 14 4 15 5	Manual Filter 00=0 01=1 02=2 03=3 04=4 05=5 06=6 07=7 08=8 09=9 Auto Filter 10 0 11=1 12 2 13 3 14 4 15=5 16=6 17 7 18 8 19=9	0=Watts 1=dBm 2=% 3=dB	A=A B=B	0 Off 1=On	0=Off 1=On	0=Free Run 1=Hold	0 GTO 1 GT1 2=GT2	0=Disabled 1=Enabled	0=In limits 1=Over high limit 2 Under low limit 3 Over high limit and under low limit

Figure 3-6. Status Message Information

Table 3-5. Response to a Clear Message (and PRESET)

Parameter	Condition
Sensor A	
CAL ADJ	100.0%
CAL FACTOR	100.0%
OFFSET	0.00 dB
Filter	AUTO
Range	AUTO
Low Limit	0.000 dBm
High Limit	0.000 dBm
Sensor B	
CAL ADJ	100.0%
CAL FACTOR	100.0%
OFFSET	0.00 dB
Filter	AUTO
Range	AUTO
Low Limit	0.000 dBm
High Limit	0.000 dBm
Display	Sensor A
OSC	Off
Entry Channel	SET A
Measurement Units	WATT
Limits Checking	Off
REL	Off
Trigger Mode	Free Run
Group Execute Trigger Mode	GT2
Display Function	Display Enable

Table 3-6. Response to a Trigger Message

Program Code	Power Meter Response
GT0	Ignore Group Execute Trigger
GT1	Trigger Immediate (TR1)
GT2	Trigger with Delay (TR2)

3-25. Receiving the Remote Message

The Remote message has two parts. First, the remote enable bus control line (REN) is held true, then the device listen address is sent by the controller. These two actions combine to place the Power Meter in remote mode. Thus, the Power Meter is enabled to go into remote when the controller begins the Remote message, but it does not actually switch to remote until addressed to listen the first time. No instrument settings are changed by the transition from local to remote. When actually in remote, the Power Meter lights the front panel RMT annunciator.

3-26. Receiving the Local Message

The Local message is the means by which the controller sends the Go To Local (GTL) bus command. If addressed to listen, the Power Meter returns to front panel control when it receives the Local message. If the instrument was in local lockout when the Local message was received, front panel control is returned, but lockout is not cleared. Unless it receives the Clear Lockout/Set Local message, the Power Meter will return to local lockout the next time it goes to remote. No instrument settings are changed by the transition from remote to local.

When the Power Meter goes to local mode, the front panel RMT annunciator turns off. However, when the Power Meter is being addressed (whether in local or remote), its front panel LSN or TLK annunciator lights.

3-27. Receiving the Local Lockout Message

The Local Lockout message is the means by which the controller sends the Local Lockout (LLO) bus command. If in remote, the Power Meter responds to the Local Lockout message by disabling the front panel LCL key. The local lockout mode prevents loss of system control due to someone accidentally pressing front panel keys. If, while in local, the Power Meter is enabled to remote (that is, REN set true) and it receives the Local Lockout message, it will switch to remote mode with local lockout the first time it is addressed to listen. When in local lockout, the Power Meter can be returned to local only by the controller (using Local or Clear Lockout/Set Local messages) or by setting the LINE switch to OFF and back to ON or by removing the bus cable.

3-28. Receiving the Clear Lockout/Set Local Message

The Clear Lockout/Set Local message is the means by which the controller sets the Remote Enable (REN) bus control line false. The Power Meter returns to local mode (full front panel control) when it receives the Clear Lockout/Set Local message. When the Power Meter goes to local mode, the front panel RMT annunciator turns off.

3-29. Receiving the Pass Control Message

The Power Meter does not respond to the Pass Control message because it cannot act as a controller.

3-30. Sending the Require Service Message

The Power Meter sends the Require Service message by setting the Service Request (SRQ) bus control line true. The instrument can send the Require Service message in either local or remote mode. When the Power Meter is sending the Require Service message, the front panel SRQ annunciator lights. The Require Service message is cleared when a serial poll is executed by the controller or when a "CS" (clear status) program code is received via a Data message.

There are five conditions that can be enabled to cause the Require Service message to be sent. These conditions, which are enabled by the Service Request Mask, are described below.

Data Ready: when the Power Meter has a data point requested by a trigger command.

Cal/Zero Completed: when the Power Meter has completed a calibration or zeroing cycle.

Entry Error: when a number is entered that is out of the allowable range for the selected parameter.

Measurement Error: when the power applied to the sensors is incorrect for the current instrument configuration.

Over/Under Limits: when the limits checking function is enabled and the measured power is greater than the high limit or lower than the low limit.

Service Request Mask. The Service Request Mask determines which bits can set the Status Byte's RQS bit true (see Figure 3-7). When the RQS bit is true, the SRQ bus line is also true.

The Service Request Mask is set by the program code "@1" followed by an 8-bit byte (a Data message). The value of the byte is determined by summing the weight of each bit to be checked. Each bit, if true, enables the corresponding condition to set the RQS bit true. At turn-on, the Service Request Mask is cleared (that is, set to 0).

Sending the Service Request Mask Value (a Data Message). After receiving an RV program code (Service Request Mask value) and when addressed to talk, the Power Meter will send a single binary word (8 bits) that describes the present state of the mask. The bit pattern can be interpreted with the information in Figure 3-7.

NOTE

This byte is sent with the bus EOI line true, thus terminating the message.

3-31. Sending the Status Byte Message

After receiving a Serial Poll Enable (SPE) bus command and when addressed to talk, the Power Meter sends the Status Byte message. The Status Byte message consists of one 8-bit byte in which five of the bits are set according to the conditions described under Sending the Require Service Message. The bit pattern of the Status Byte is shown in Figure 3-7. Note that bits 6 and 8 are always set to 0. The remaining bit is the RQS bit.

If one or more of the five conditions described above is both present and enabled by the Service Request Mask, the bits corresponding to the conditions and also bit 7, the RQS bit, are set true (and the Require Service message is sent). If one or more of the five conditions occurs but has not been enabled by the Service Requst Mask, the corresponding bits are still set true. However, if a condition has not been enabled by the mask, it cannot cause the RQS bit to be set true.

Once the Power Meter receives the serial poll enable (SPE) bus command, it is no longer able to alter the status byte. If a bit has been enabled and that

Bit	8	7	6	5	4	3	2	1
Weight	128	64	32	16	8	4	2	1
Condition	0	RQS Bit Require Service	0	Over/ Under Limit	Measure-ment Error	Entry Error	Cal/ Zero Complete	Data Ready

Figure 3-7. The Status Byte and Service Request Mask

Sending the Status Byte Message (cont'd)

condition occurs after the RQS bit has been set true, the bit is stored in a buffer and is read the next time the Power Meter receives the SPE bus command.

After the Status Byte message has been sent, it will be cleared if the Serial Poll Disable (SPD) bus command is received, if the Abort message is received, or if the Power Meter is unaddressed to talk. Bits stored in the buffer waiting to be read, however, are not cleared. Regardless of whether or not the Status Byte message has been sent, the Status Byte and any Require Service message pending will be cleared if a Clear Status (CS) program code is received by the Power Meter.

3-32. Sending the Status Bit Message

The Power Meter sends the Status Bit message (if configured to do so) as part of the interface's response to the Parallel Poll Enable (PPE) bus command. In order for the Power Meter to respond to a PPE bus command, the instrument must be assigned a single HP-IB data line on which to respond by the controller. The controller also assigns the logic sense of the bit. Both tasks are accomplished by the Parallel Poll Configure (PPC) bus command. If the Power Meter is sending the Require Service message, it will set its assigned status bit true. The Power Meter can send the Status Bit message without being addressed to talk.

The data line on which the Power Meter is assigned to respond is cleared by sending the Parallel Poll Unconfigure (PPU) bus command. At turn-on, the data line is unassigned.

3-33. Receiving the Abort Message

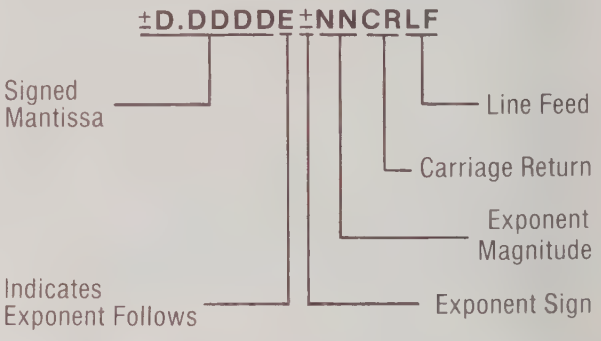
The Abort message is the means by which the controller sets the Interface Clear (IFC) bus control line true. When the Abort message is received, the Power Meter becomes unaddressed and stops talking and listening.

3-34. HP-IB Syntax and Characteristics Summary

Address: Set in decimal from the front panel. Set the LINE switch to ON while pressing the LCL key. Release the LCL key, enter the desired address, and press the ENTER key. Factory set to 13.

Data Input Format: Typically the same as front panel keystrokes in local mode. All numeric entries sent over the HP-IB must be terminated with program code "EN" (for ENTER).

Data Output Format: Output format when no other talk mode has been defined:



Output format for Learn Mode #1 (program code LP1): Up to 128 ASCII characters [EOI]

Output format for Learn Mode #2 (program code LP2): 30 bytes [EOI]

Output format for Identification (program code ?ID): HP438AVERx.xx [EOI]

Output format for Status Message (program code SM): 23 ASCII characters [EOI]

Output format for Service Request Mask Value (program code RV): 1 byte [EOI]

Return to Local: Front panel LCL key if not locked out.

HP-IB Syntax and Characteristics Summary (cont'd)

Status Byte:

Bit	8	7	6	5	4	3	2	1
Weight	128	64	32	16	8	4	2	1
Service Request Condition	0	RQS Bit Require Service	0	Over/ Under Limit	Measure-ment Error	Entry Error	Cal/Zero Complete	Data Ready

Notes: 1. The condition indicated in bits 1-5 must be enabled by the Service Request Mask to cause a Service Request Condition. The mask is set with the @1 program code followed by an 8-bit byte. The value of the byte is determined by summing the weight of each bit to be checked.

2. The RQS bit (bit 7) is true when any of the conditions of bits 1-5 are enabled and occur.

3. Bits remain set until the Status Byte is cleared.

Complete HP-IB Capability (as described in IEEE Std 488-1978, and ANSI Std MC1.1): SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP1, DC1, C0.

Table 3-7. HP-IB Codes to Parameter Summary

HP-IB Code*	Parameter	HP-IB Code*	Parameter
AD	Sensor A minus Sensor B measurement	*LH	High Limit
AE	SET A	*LL	Low Limit
AP	Sensor A measurement	LM0	Disable limits checking function
AR	A/B ratio measurement	LM1	Enable limits checking function
BD	Sensor B minus Sensor A measurement	LN	Linear (Watts or %)
BE	SET B	LP1	Learn Mode #1
BP	Channel B measurement	LP2	Learn Mode #2
BR	B/A ratio measurement	OC0	Reference Oscillator off
*CL	CAL ADJ	OC1	Reference Oscillator on
CS	Clear Status Byte	*OS	OFFSET
DA	Display All	PR	PRESET
DD	Display Disable	RA	AUTO RANGE
DE	Display Enable	*RC	RECALL
DO	DSP → OFS	RH	Range Hold
EN	ENTER	RL0	Exit REL mode
FA	AUTO FILTER	RL1	Enter REL mode
FH	Filter Hold	*RM	MNL RANGE
*FM	MNL FILTER	RV	Service Request Mask Value
GT0	Ignore Group Execute Trigger (GET) bus command	SM	Status Message
GT1	Trigger Immediate response to Group Execute Trigger	*ST	STORE
GT2	Trigger with Delay response to Group Execute Trigger	TR0	Trigger Hold
*KB	CAL FACTOR	TR1	Trigger Immediate
LG	Log (dB or dBm)	TR2	Trigger with Delay
		TR3	Trigger - Free Run
		ZE	ZERO
		@1	Prefix for Service Request Mask
		?ID	Identification

Codes preceded by an asterisk (*) require numeric entry followed by program code EN. Do not enter the asterisk as part of the program code.

CAL ADJ

Description

CAL ADJ is used to calibrate the Power Meter and any compatible power sensor to a known reference. During the calibration cycle, the gain of the Power Meter is adjusted so that the front panel display reads 1.000–3 (1 mW) when the sensor is connected to a 1.00 mW reference oscillator.

Pressing the CAL ADJ key enables entry of the reference calibration factor for the active entry channel. The reference calibration factor is the sensor's calibration factor at 50 MHz. The allowable range of values for CAL ADJ is 50.0 to 120.0%.

The Power Meter calibrates to an external reference source if the entered reference calibration factor is negative. If the entered reference calibration factor is positive, the Power Meter calibrates to the 1.00 mW internal reference oscillator.

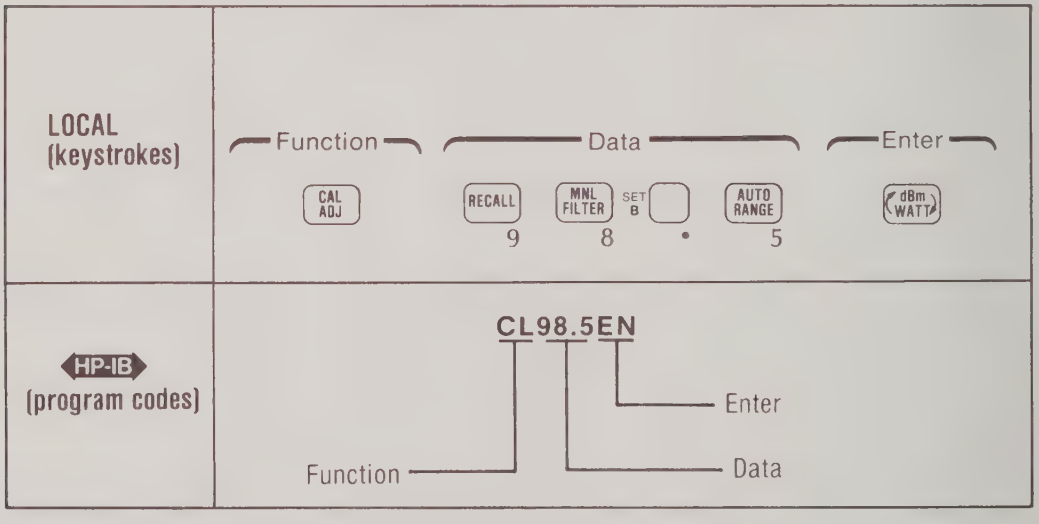
Procedure

Connnect the sensor to either channel A or channel B via a power sensor cable, and set the active entry channel accordingly. Press ZERO. (Be sure that no RF power is applied to the sensor during the zero routine.) When the Power Meter has finished zeroing, connect the sensor to the 1.00 mW reference oscillator. Press CAL ADJ, enter the reference calibration factor in percent, and then press ENTER.

Both channels must be calibrated with their own sensors for dual sensor measurements.

Example

To calibrate a sensor to the Power Meter with a reference cal factor of 98.5%:



Program Codes HP-IB

Parameter	Program Code
CAL ADJ	CL
ENTER	EN

Indications

After the CAL ADJ key has been pressed, the display shows "ENT — — —". Once the reference cal factor has been entered, the instrument goes through its calibration routine, and the display shows eight dashes and a moving decimal point.

CAL ADJ (cont'd)

Comments

The reference calibration factor, which is entered via CAL ADJ, is used only during calibration. Calibration factors entered via CAL FACTOR are used for actual measurements.

Zero the active entry channel before entering the reference calibration factor.

The reference calibration factor can be found on the body of the sensor.

A calibration should be performed whenever the Power Meter changes power sensors or whenever the ambient temperature changes by more than 5°C.

PRESET sets CAL ADJ to 100%. The gain of the Power Meter, however, does not change until a new calibration is performed.

Pressing CAL ADJ and then ENTER without entering any data causes the Power Meter to initiate a calibration using the last entered value for CAL ADJ.

Any command received during the calibration process aborts the calibration and executes the function of the command received. The number entered for CAL ADJ, however, is stored as the last entered value.

When using the HP 8483A Power Sensor, enter a reference calibration factor of 96%, even though 100% may be indicated on the sensor's cal factor label. Using a CAL ADJ value of 96% compensates for mismatch between the 75-ohm sensor and the 50-ohm reference oscillator. Newer HP 8483A Power Sensors have the correct reference cal factor (96%) printed on the label.

If an HP 8484A Power Sensor with its associated HP 11708A Reference Attenuator is used, the front panel display reads 1.000–6 instead of 1.000–3.

Offset settings are ignored during calibration.

Error 57 occurs when the instrument is turned on and the internal RAM contents have been lost. This is generally due to battery failure, but may also occur when the Power Meter is powered down during calibration or zeroing. The error is cleared after two seconds or by selecting any other function. Once the error is cleared, the Power Meter is configured to the PRESET state and the HP-IB address is read from the internal address switch.

Because of the variety of sensor power ranges, the Power Meter always auto ranges during calibration. After calibration the previous range setting is restored.

If the CAL ADJ entry is positive, the Power Meter first checks that the sensor is connected to the reference oscillator by tunring the oscillator on and off and watching for a power level change on the sensor. If the sensor is connected, the reference oscillator is turned on for the calibration and returned to its former state upon completion of the calibration.

Related Sections

CAL FACTOR
Error Messages
SET A and SET B
PRESET
ZERO

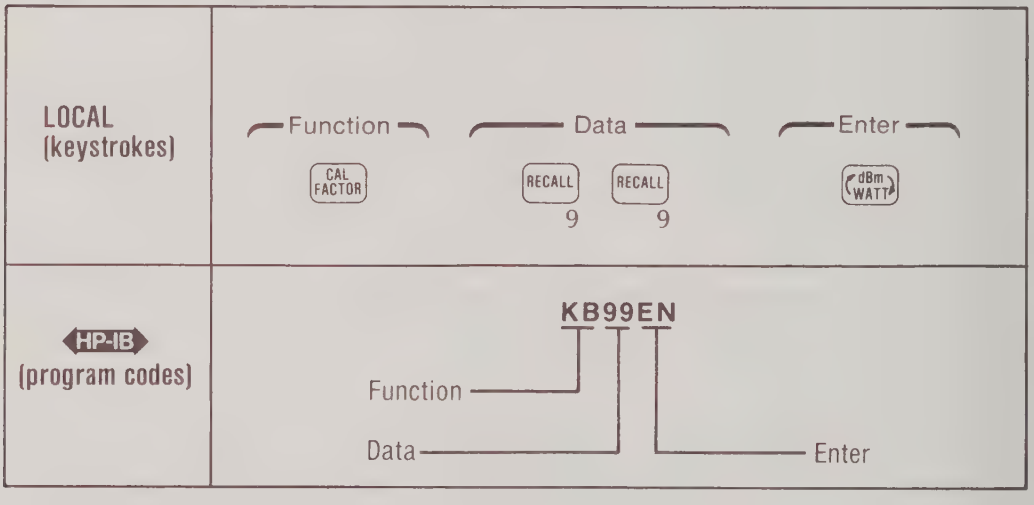
CAL FACTOR

Description The calibration factor compensates for mismatch losses and effective efficiency over the frequency range of the power sensor.

Pressing the CAL FACTOR key enables entry of the calibration factor for the sensor connected to the active entry channel. (A chart of CAL FACTOR % versus Frequency is printed on each sensor and an accompanying data sheet.) Calibration factor is entered in percent. Valid entries for CAL FACTOR range from 1.0 to 150.0%. Front panel numeric entry allows up to 4 digits. After the first four digits are entered, succeeding digits are ignored. Only one digit to the right of the decimal point is accepted. Data entered over the bus (in remote mode) is rounded to the required resolution.

Procedure Cal factor is entered separately for sensor A or sensor B. To enter the cal factor for the active entry channel, press CAL FACTOR, enter the cal factor in percent, and then press ENTER.

Example To enter a cal factor of 99%:



Program Codes HP-IB

Parameter	Program Code
CAL FACTOR	KB
ENTER	EN

Indications When the CAL FACTOR key is pressed, the front panel display shows "ENT — — —". After a number has been entered and the ENTER key has been pressed, the display returns to its previous mode.

The front panel displays the value of the calibration factor(s) used in the current measurement.

CAL FACTOR (cont'd)

Comments

During actual measurements, calibration factors entered via CAL FACTOR are used. The reference calibration factor, which is entered via CAL ADJ, is used only during the calibration cycle.

Pressing CAL FACTOR and then ENTER without entering any data sets the calibration factor to 100%.

PRESET sets the calbration factor of both sensor A and sensor B to 100%.

Related Sections

CAL ADJ
PRESET
SET A and SET B
STORE and RECALL

dBm/WATT (Logarithmic/Linear Units)

Description

The dBm/WATT key can be used to express measurement results in logarithmic or linear units. The following table shows which units are applicable to the individual measurement modes.

Measurement Mode	REL Off*		REL On*	
	Lin	Log	Lin	Log
Single Sensor	Watt	dBm	%	dB
Ratio	%	dB	%	dB
Difference	Watt	dBm	%	dB

*When REL (relative mode) is on, the measurement is compared to a reference value. The reference value is the first value read when REL is activated.

The dBm/WATT key allows any measurement result to be viewed in logarithmic or linear format.

Procedure

Pressing the dBm/WATT key alternates the display between the logarithmic and the linear functions. When the measurement mode is changed, the logarithmic or linear setting of the dBm/WATT key remains the same.

Example

If the display shows 1.000 mW, to display this value in dBm:

LOCAL (keystrokes)	dBm WATT
HP-IB (program codes)	LG

Program Codes HP-IB

Parameter	Program Code
Logarithmic Units (dBm or dB)	LG
Linear Units (Watts or %)	LN

dBm/WATT (Logarithmic/Linear Units) (cont'd)

Indications

The status of the dBm/WATT key can be determined by observing the current measurement mode, the measurement unit annunciators, and the table above.

Comments

Logarithmic units cannot be used with a measured value that is zero or negative. If the value is zero or negative, Error 27 (illegal logarithmic operation) will be displayed.

With REL mode off, logarithmic units cannot be used to display A–B difference measurements where the SENSOR A power level is less than the SENSOR B power level. Likewise (with REL mode off), logarithmic units cannot be used to display B–A difference measurements where the SENSOR B power level is less than the SENSOR A power level.

PRESET sets the measurement units to Watts (linear units).

With no power applied to the sensor, the displayed power in single sensor measurement mode dirfts both negative and positive (about zero). If the Power Meter is in logarithmic mode, negative drift results in a log error (Error 27). This is normal and does not require corrective action.

Related Sections

Error Messages
PRESET
REL (Relative Measurements)
SENSOR A–B and SENSOR B–A

Error Messages

Description

The Power Meter generates error messages to indicate operating problems, incorrect keyboard or HP-IB entries, and service-related problems.

Error messages are grouped as follows:

Errors 01 through 49. These are measurement errors, which indicate that not all conditions have been met to assure a calibrated measurement. Measurement errors can usually be cleared by readjusting the front panel controls or changing the equipment setup.

Errors 50 through 59 and 90 through 99. These are entry errors, which indicate that an invalid keyboard or HP-IB entry has been made. These errors require that a new entry or function selection be made.

Errors 60 through 69. These are service errors, which provide service-related information. Service errors are discussed in Section VIII of the manual.

Error Displays

Errors are indicated on the front panel. The left side of the display shows a brief message (eight characters or less) indicating the nature of the problem. The right side of the display indicates the error code. In addition, the channel on which the error occurs is indicated in the right side of the display for some errors.

HP-IB Output Format

As long as the front panel display indicates an error condition, the instrument sends 9.0000E+40 as the measured data when addressed to talk.

If an error condition generates SRQ, the status byte and status message latch the error until the status message (program code SM) has been read by the HP-IB controller. Once the status message has been read, the status byte and status message are cleared if the error condition no longer exists. If multiple errors occur, the status message indicates the most recent error.

If an error condition does not generate SRQ (for example, the Service Request Mask has been set such that measurement or entry errors do not set the status byte's RQS bit true), the status byte and status message latch all entry errors. Measurement errors, however, are latched only if 9.0000E+40 has been sent over the HP-IB. The status byte and status message are cleared by removing the cause of the error and then reading the status message over the HP-IB.

Error Messages

Table 3-8, Error Messages, describes all measurement and entry errors. The error code, front panel error display, message, and action typically required to remove the error-causing condition are given. The Footnotes column refers to additional information and references pertaining to particular errors.

Table 3-8. Error Messages (1 of 3)

Error Code	Error Display	Message	Action Required	Foot-notes
		Measurement Errors		
01	Cannot 0	Power Meter cannot zero sensor A	Ensure that no RF power is being applied to sensor A	
02	Cannot 0	Power Meter cannot zero sensor B	Ensure that no RF power is being applied to sensor B	
03	no rEF	Sensor is not connected to reference oscillator during calibration	Connect sensor A to reference oscillator. Enter a negative reference cal factor if an external reference source is used. If error persists, check output of reference oscillator.	
04	no rEF	Sensor B is not connected to reference oscillator during calibration	Connect sensor B to reference oscillator. Enter a negative reference cal factor if an external reference source is used. If error persists, check output of reference oscillator	
05	Cal-Err	Power Meter cannot calibrate sensor A	Check sensor A connection to reference oscillator. Reference must be 1.00 mW.	
06	Cal-Err	Power Meter cannot calibrate sensor B	Check sensor B connection to reference oscillator. Reference must be 1.00 mW.	
11	inPut-OL	Input overload on sensor A	Reduce input power to sensor A	1
12	inPut-OL	Input overload on Sensor B	Reduce input power to sensor B	1
15	PLEASE 0	Sensor A's zero reference has drifted negative	Zero sensor A. If error persists, check input power.	
16	PLEASE 0	Sensor B's zero reference has drifted negative	Zero sensor B. If error persists, check input power.	
17	up rng	Input power on sensor A is too high for current range	Select a higher range or reduce input power to sensor range A	2
18	up rng	Input power on sensor B is too high for current range	Select a higher range or reduce input power to sensor B	2
25	CALC OF	Overflow error	Change either the input power, offset, cal factor or measurement mode	3

1. This error occurs when the input power exceeds 120% of the full-scale power for range 5 and only when the Power Meter is on range 5.

2. This error occurs when the Power Meter is on manual range and the input power exceeds 120% of full-scale for ranges 1, 2, 3, and 4.

3. Power calculations result in a value that is too large to calculate or display. The combination of input power, offset, cal factor and measurement mode results in a value whose absolute value is greater thatn 3.4028E+38.

Table 3-8. Error Messages (2 of 3)

Error Code	Error Display	Message	Action Required	Foot-notes
		Measurement Errors (cont'd)		
26	CALC UF	Underflow error	Change either the input power, offset, cal factor or measurement mode	4
27	LOf Err	Ilegal logarithmic operation	Change to linear measurement units, zero the Power Meter with no RF input power, or increase input power to greater than 0 Watts	
28	rEL Err	Invalid or missing reference value	Exit REL mode	5
31	no Ch a	Channel A does not have a sensor connected to it	Connect a sensor to channel A or change channels (assuming a sensor is connected to channel B)	
32	no Ch b	Channel B does not have a sensor connected to it	Connect a sensor to channel B or change channels (assuming sensor is connected to channel A)	
33	2 inPuts	Both front and rear sensor A inputs have sensors connected (Option 002 only)	Remove one of the 2 sensors connected to sensor A input	
34	2 inPuts	Both front and rear sensor B inputs have sensors connected (Option 002 only)	Remove one of the 2 sensors connected to sensor B input	
		Entry Errors		
50	CF Error	Entered cal factor is out of range	Re-enter value between 1.0 and 150.0	6
51	OS Error	Entered offset is out of range	Re-enter value between -99.99 and +99.99	6
52	rg Error	Entered range number is out of range	Re-enter range number between 1 and 5	6
53	FL Error	Entered filter number is out of range	Re-enter filter number between 0 and 9	6

4. Power calculations result in a value that is too small to calculate or display. The combination of input power, offset, cal factor and measurement mode results in a value whose absolute value is greater than 1.1755E-38.

5. This error is cleared after two seconds or by selection of any other function.

6. This error indication is cleared after two seconds or by selecting any function. (The selected function will be executed.) When the error is cleared, the parameter that caused the error remains unchanged from its previous value.

Table 3-8. Error Messages (3 of 3)

Error Code	Error Display	Message	Action Required	Foot-notes
		Entry Errors (cont'd)		
54	rc Error	Entered recall register number is out of range	Re-enter register number between 0 and 19	6
55	st Error	Entered storage register number is out of range	Re-enter register number between 1 and 19	6
56	rCF Err	Entered reference cal factor is out of range	Re-enter CAL ADJ value between 50.0 of range and 120.0	6
57	rCL FaiL	Continuous memory failure	Refer to Footnotes below	7
58	Ad Error	Entered HP-IB address is out of range	Re-enter HP-IB address between range 0-30, 40-49, or 50-59	6
90		HP-IB data without valid prefix	Check, then re-enter valid prefix with data	
91		Invalid HP-IB code	Check, then re-enter correct HP-IB code	
		Hardware Errors		
61-69		Service-related errors	Refer to Service-Related Errors in Section VIII, Service	

6. This error indication is cleared after two seconds or by selecting any function. (The selected function will be executed.) When the error is cleared, the parameter that caused the error remains unchanged from its previous value.

7. Error 57 occurs when the instrument is turned on and the internal RAM contents have been lost. This is generally due to battery failure, but may also occur when the Power Meter is powered down during the end of a zero or calibration sequence. The error indication is cleared after two seconds or by selecting any other function. (The selected function will be executed.) Once the error indication is cleared, the Power Meter is configured in the PRESET state and the HP-IB address is taken from the value that is defined on the internal address switch.

Filters

(Includes AUTO FILTER and MNL Filter)

Description

The purpose of filtering is to reduce jitter in the display. Measured values are averaged with previous values before being displayed.

The Power Meter uses a variable digital filter to average power readings. The value shown in the display is the average of the last 2^N readings, where 2^N is the filter length and N is the filter number. The filter length can range from 1 (2^0) to 512 (2^9).

When a new power measurement is input to the filter, it is saved and the oldest reading is discarded. If the Power Meter's configuration changes such that the values in the filter are no longer valid (for example, a change in measurement mode, range or filter setting), the filter contents are set to zero. The filter starts filling up again, and the Power Meter displays the average of the accumulated power readings.

The filter length can be selected automatically (via AUTO FILTER) or manually (via MNL FILTER). For most applications, auto filter is the best mode of operation. Manual filter mode is useful mainly in specialized applications requiring high resolution or fast settling times.

In auto filter mode, the Power Meter automatically sets the filter length to satisfy the filtering requirements for most power measurements. The filter length depends solely upon the power range in which the Power Meter is currently operating. The following table lists the filter length and filter number for each range when the Power Meter is in auto filter mode.

Auto Filter Setting for Each Range

Range	Filter Length	Filter Number
1	128	7
2	8	3
3	2	1
4	1	0
5	1	0

When the filtering is selected automatically, the resolution is four significant digits for measurements displayed in Watts or percent. The resolution is 0.01 dB for measurements displayed in dB or dBm.

In manual filter mode, the filter length is selected by entering a filter number between 0 and 9. Refer to the following table to cross-reference filter numbers to filter lengths.

Filters (cont'd)

Filter Number	Filter Length
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512

Note that the filter length is independent of the measurement power range when the filter length is set manually.

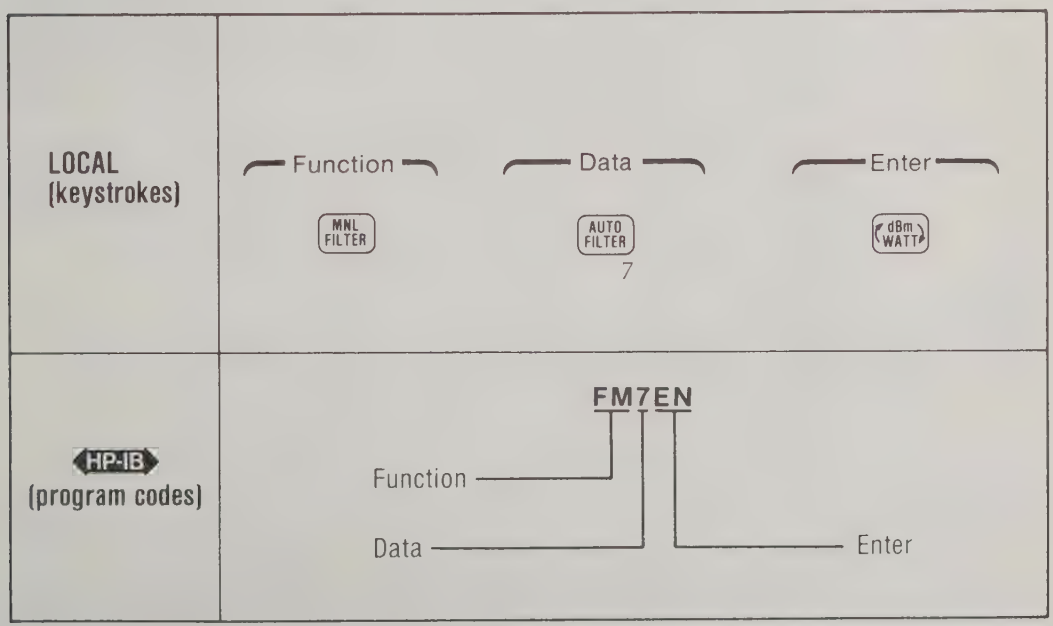
An additional feature of the Power Meter is the hold filter mode. Hold filter mode provides a means of switching from auto filter mode to manual filter mode while retaining the auto filter setting.

Procedure

The filter length is set for the active entry channel. For dual sensor measurements, the filter length should be set for each sensor. To automatically select the filter length, press AUTO FILTER. To manually select the filter length, press MNL FILTER, enter a number (0 — 9), and then press ENTER. (The filter length is the result of 2 being raised to the power of the filter number.) To select hold filter mode, press MNL FILTER and then ENTER.

Example

To manually set the filter length to 128 (filter number=7):



Filters (cont'd)

Program Codes HP-IB

Parameter	Program Code
AUTO FILTER	FA
MNL FILTER	FM
Hold Filter	FH
ENTER	EN

Indications

The MNL annunciator on the front panel display lights when the Power Meter is in manual filter or manual range mode. There is no front panel indication when the Power Meter is in auto filter mode.

Comments

By manually selecting a filter length that is significantly longer than the auto filter mode default length, the resolution of the display can be extended to five digits in Watts or to 0.001 in dBm on some power ranges. The range setting and filter number required for high resolution is defined in the following table.

Range	Filter Number Required For High Resolution
1	High resolution not available
2	8, 9
3	5, 6, 7, 8, 9
4	4, 5, 6, 7, 8, 9
5	3, 4, 5, 6, 7, 8, 9

In auto filter mode, the average of the last four values entered into the filter is compared to the average of the entire filter. If the difference between the two averages is greater than 12.5%, the contents of the digital filter are set to zero. The filter then starts storing new measurement values, and Power Meter displays the average of accumulated power readings. This feature shortens the settling time of the Power Meter when the input power changes substantially.

Only one digit is allowed for MNL FILTER data entries. If a second digit is entered, it replaces the one that is already there. The decimal point and ± keys are ignored.

PRESET sets both sensor A and sensor B to auto filter mode.

Related Sections

PRESET
Range
SET A and SET B
STORE and RECALL

Limits

Description

The limits checking function allows the Power Meter to monitor the power level on each sensor and to indicate when that power is outside preset limits. High and low limits can be set, and the limits checking function is enabled only via remote programming.

Limit values are entered in dBm and need not be the same for each sensor. Allowable values range from −299.999 to +299.999 dBm. Values entered outside this range cause the limit to be set to the minimum or maximum value as appropriate.

When the limits checking function is enabled, the Power Meter uses the last high and low limit values set for each sensor.

Procedure

To set a high limit or a low limit for the active entry channel:

a. Address the Power Meter to listen.

b. Send a program string (in a Data message) consisting of program code LL (limit low) or LH (limit high), a numeric value, and program code EN (ENTER).

To enable the limits checking function, address the Power Meter to listen and then send a Data message with program code LM1. The limits checking function is disabled by program code LM0.

Example

To set sensor A's low limit to +10 dBm and high limit to +20 dBm, and to enable the limits checking function:

LOCAL (keystrokes)	(not available in local)
HP-IB (program codes)	**AELL10ENLH20ENLM1** SET A Low Limit High Limit Enable Limits Checking

Program Codes HP-IB

Parameter	Program Code
Low Limit	LL
High Limit	LH
Enable Limits Checking	LM1
Disable Limits Checking	LM0

Limits (cont'd)

Indications

If the limits checking function is enabled and the input power exceeds the high limit or is less than the low limit, the out-of-limits condition is indicated on the front panel by a flashing A or B annunciator, depending on the measurement mode. The out-of-limits condition is indicated only for sensors used in the current measurement. For dual sensor measurements, the out-of-limits condition is indicated for the sensor(s) out of limits.

The out-of-limits condition can be indicated over the bus by setting the Service Request Mask to enable an out-of-limits condition to issue the Require Service Message, thus lighting the SRQ annunciator on the front panel.

Comments

PRESET sets both the high and low limits for each sensor to 0.000 dBm and disables the limits checking function.

Limits are checked against measured power plus offsets.

By setting the low limit to a value greater than the high limit (or setting the high limit to a value less than the low limit), a region can be defined. An out-of-limits condition occurs anytime displayed power drifts into this region (assuming the limits checking function is enabled).

If the limits checking function is enabled in remote mode and then the Power Meter is switched to local operation, the limits checking function remains enabled.

High and low limits cannot be stored or recalled.

Related Sections

PRESET
Remote Operation, HP-IB
SET A and SET B
STORE and RECALL

OFFSET

Description

Offset values can be entered to each channel to compensate for gain or loss. The offset is added to the measured power before the result is displayed.

Offsets are entered in dB. The allowable range of values is -99.99 to +99.99 dB in 0.01 dB increments. Use positive values for gain and negative values for loss. Pressing the OFFSET key and then the ENTER key (without entering any data) sets the offset of the active entry channel to 0.00 dB.

The display offset function provides another method for entering offset values. Pressing OFFSET, DSP → OFS, and then ENTER automatically enters the offset necessary for the Power Meter's display to indicate 0.00 dB or dBm for logarithmic units, or 100% or 1.00 mW for linear units, depending on the measurement mode. Existing offsets are taken into account in the calculation of the display offset value.

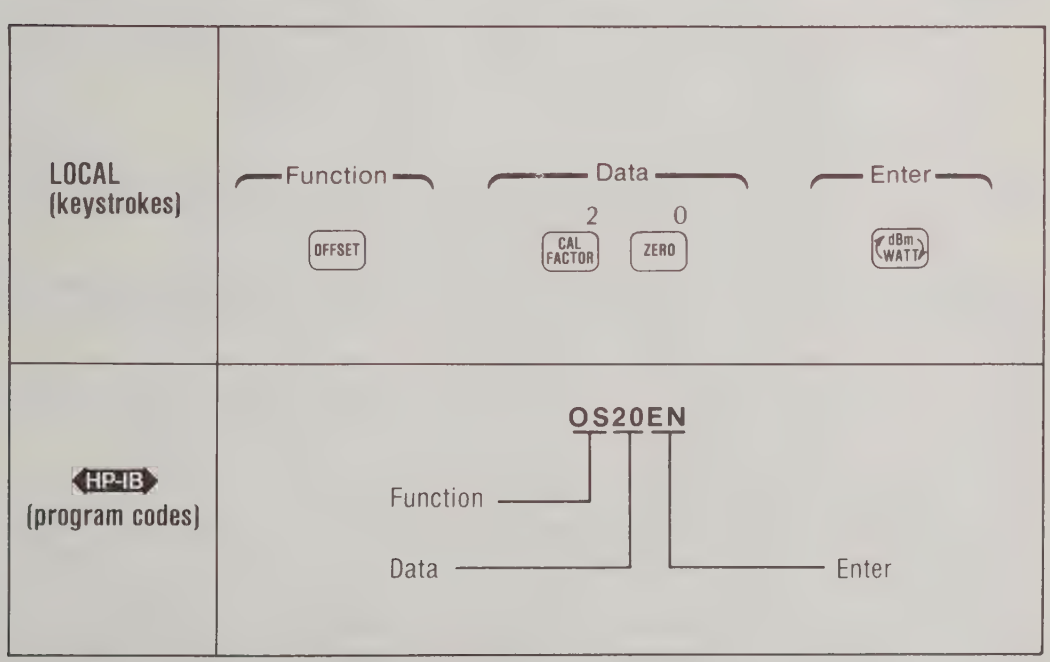
Procedure

To enter an offset for the active entry channel, press OFFSET, enter a value between −99.99 and +99.99 dB and then press ENTER.

To enter the offset necessary for the Power Meter to display 0.00 dB or dBm, 100%, or 1.00 mW (depending on the measurement mode), press OFFSET, DSP → OFS, and then ENTER.

Examples

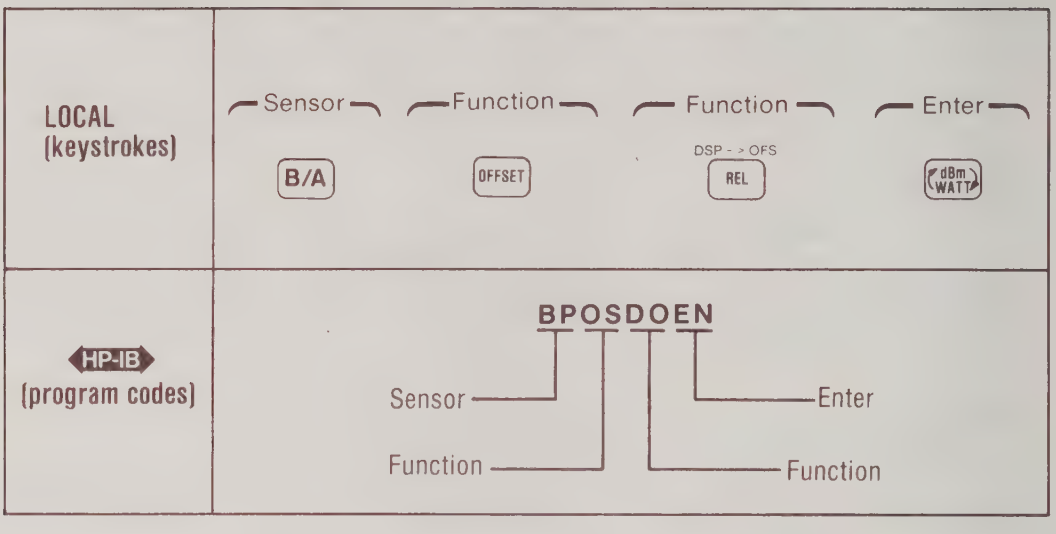
To add a 20 dB offset to channel B (assuming that channel B is the active entry channel):



The next example uses the display offset function to compensate for the coupling factor of a directional coupler. Connect sensor A to the coupler's test port, and connect sensor B to the coupler's incident port. To enter the correct offset for sensor B to read the power emerging from the directional coupler (correcting for any main line insertion loss as well as coupling factor):

OFFSET (cont'd)

Example (cont'd)



Program Codes HP-IB

Parameter	Program Code
OFFSET	OS
Display Offset	DO
ENTER	EN

Indications

When an offset is added to a measurement, the front panel displays the value of the offset and the "dBOS" annunciator lights.

Comments

A dB offset can be added to a sensor whose display is in Watts. The Power Meter automatically converts the dB offset to Watts and adds that value to the sensor's measured power.

The following equations are used to calculate the value that is entered for the display offset function.

For measurement modes A–B or A/B:

Display Offset of active entry channel =

a. Current OFFSET (active entry channel) – 10 * LOG $\left[\frac{\text{Power (B)} + \text{OFFSET (B)}}{\text{Power (A)} + \text{OFFSET (A)}}\right]$.

b. Current Offset (active entry channel) + 10 * LOG $\left[\frac{\text{Power (B)} + \text{Offset (B)}}{(\text{Power (A)} + \text{OFFSET (A)})}\right]$.

c. Current Offset (active entry channel) – 10 * LOG [Power (active entry channel)].

If the display offset value as calculated above results in an illegal offset entry value, the number 999.9 will be displayed. The Power Meter generates Error 51 (offset entry error) if an attempt to enter the illegal value is made.

OFFSET (cont'd)

Comments cont'd

Display offset function ignores REL mode when calculating the offset value.

PRESET sets both the sensor A and sensor B offset values to 0.00 dB.

The DSP → OFS function is only active when it is preceeded by OFFSET.

Related Sections

dBm/WATT (Logarithmic/Linear Units)
Error Messages
PRESET
REL (Relative Measurements)
SET A and SET B
STORE and RECALL

PRESET

Description

The PRESET key sets the Power Meter to a known state. Preset conditions are shown in Table 3-9.

Table 3-9. PRESET Conditions

Parameter	Condition
Sensors A and B	
CAL FACTOR	100.0%
CAL ADJ	100.0%
OFFSET	0.00 dB
Filter	Auto
Range	Auto
Meaurement Mode	Sensor A
Reference Oscillator (OSC)	Off
Active Entry Channel	A
Measurement Units	Watts
REL	Off
Remote Only Functions	
Sensors A and B	
Low Limit	0.000 dBm
High Limit	0.000 dBm
Limits Checking	Disabled
Trigger Mode	Free Run
Group Trigger Mode	Trigger with Delay
Display Function	Display Enable

Procedure

To set the Power Meter to the conditions indicated in Table 3-9, press the PRESET key.

Program Codes

HP-IB

The program code for PRESET is PR.

Comments

PRESET does not affect zero and calibration information stored for each sensor. Although PRESET sets the CAL ADJ value to 100.0%, it does not initiate a calibration using the new value for CAL ADJ.

PRESET produces the same results as the Device Clear command over the HP-IB.

Storage register 0 is set to the preset condition when a continuous memory error (Error 57) occurs.

Related Sections

CAL ADJ
CAL FACTOR
dBm/WATT (Logarithmic/Linear Units)
Error Messages
Filters
Limits
OFFSET
Range
REL (Relative Measurements)
STORE and RECALL

RANGE

(Includes AUTO RANGE and MNL RANGE)

Description

The Power Meter divides each sensor's power range into 5 ranges of 10 dB each. Range 1 is the most sensitive (lowest power levels), and Range 5 is the least sensitive (highest power levels). Range 5 can be less than 10 dB if the sensor's power range is less than 50 dB. The range can be set either automatically or manually for the active entry channel.

AUTO RANGE automatically selects the correct range for the current measurement.

MNL RANGE enables the range to be selected manually. Valid range numbers are 1 through 5. Only one digit is permitted for range entries. If a second digit is entered, it replaces the first digit.

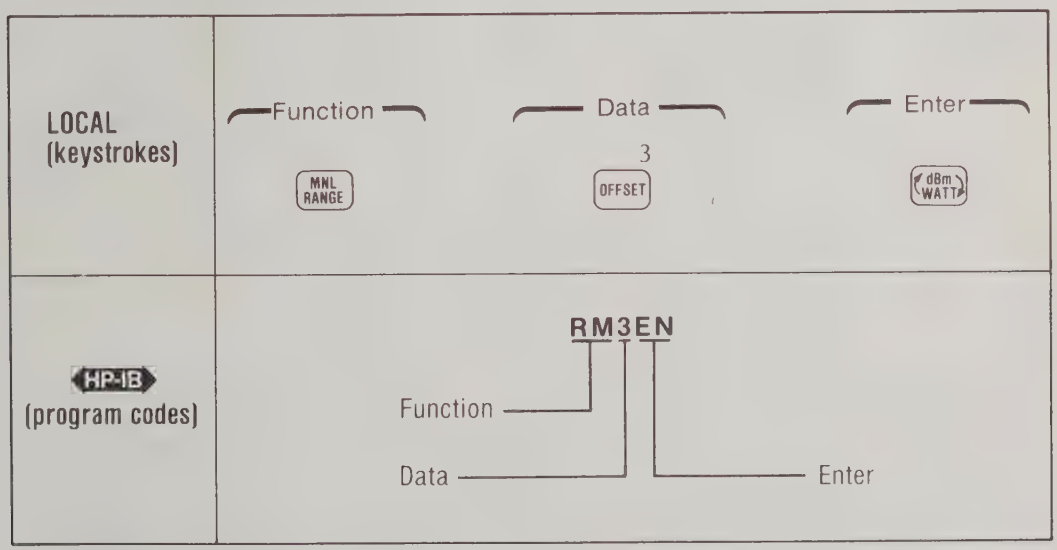
Another feature of the Power Meter is the hold range mode. Hold range provides a means of switching from auto range to manual range while retaining the current auto range setting.

Procedure

To select auto range, press AUTO RANGE. To select manual range, press MNL RANGE, enter a numeric value and then press ENTER. To select hold range mode, press the MNL RANGE key and then the ENTER key.

Example

To select range 3 manually:



Program Codes HP-IB

Parameter	Program Code
AUTO RANGE	RA
MNL RANGE	RM
Hold Range	RH
ENTER	EN

Range (cont'd)

(Includes AUTO RANGE and MNL RANGE)

Indications

The MNL annunciator on the front panel display lights when the Power Meter is in manual or hold range mode, or manual or hold filter mode. There is no front panel indication when the Power Meter is auto ranging.

Comments

PRESET sets both sensor A and sensor B to AUTO RANGE.

If you are only interested in power readings in one range, manual range can be used for faster readings.

Use manual range when using the rear panel RCDR output so that the Power Meter does not change ranges while outputting data. The recorder output provides a 0 to 1 Vdc output for each range.

Pressing the AUTO RANGE key when the Power Meter is already in auto range mode causes the instrument to step down one range, if possible. (There is a 20% overlap on ranges.) If the power reading can be displayed on either range, the Power Meter stays on the lower range. In linear mode, this provides a means for down ranging to obtain greater resolution in borderline situtations. For example, with an HP 8481A power sensor measuring a power level of 1.153 mW, the range could be either range 4 (1 to 10 mW) or range 3 (0.1 to 1.2 mW with 20% overrange). The display in range 4 would show 1.15 mW, but in range 3 would show 1.153 mW.

Related Sections

Error Messages
PRESET
Recorder Output
SET A and SET B

Recorder Output

Description

The rear panel RCDR output produces a dc voltage that corresponds to the power level in Watts of sensor A or sensor B, depending on the measurement mode. Only single sensor power measurements produce a valid dc output voltage at the RCDR output. The RCDR output is disabled (0V) during dual sensor and relative measurements. This dc voltage ranges from 0 to +1.0 Vdc. For each of the Power Meter's five ranges, +1.0 Vdc corresponds to a full-scale indication. The output impedance is 1 kΩ.

Some uses of the RCDR output include recording swept measurements on an X-Y recorder, leveling input for external ALC, or monitoring output power on a strip chart recorder. A setup for recording swept measurements is shown in Figure 3-8.

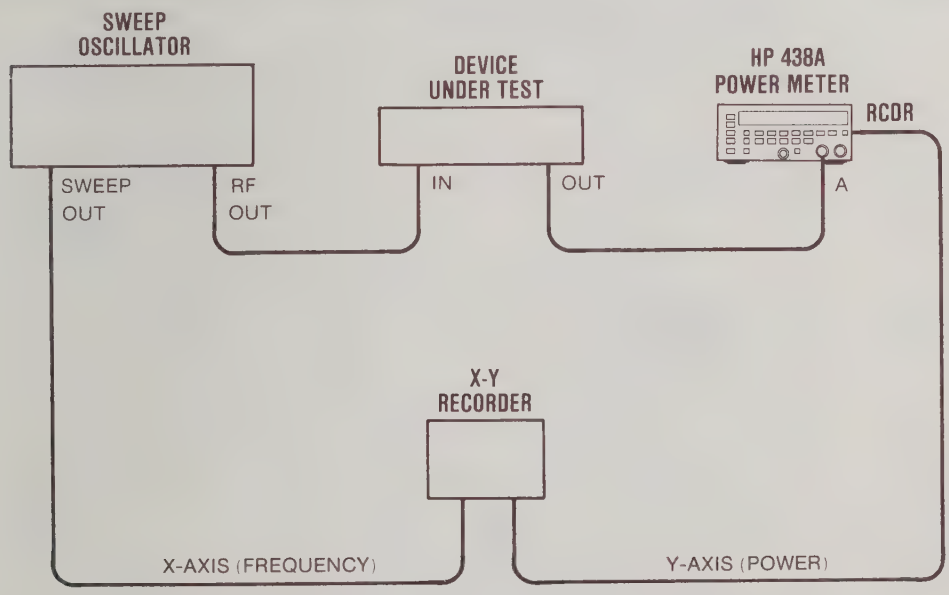


Figure 3-8. Test Setup For Recording Swept Measurements

Comments

Cal factor and offsets have no effect on the recorder output.

The most stable results are obtained on ranges 3, 4, and 5.

Use MNL RANGE when using the RCDR output to prevent the Power Meter from changing ranges while outputting data.

Related Sections

Range
REL (Relative Measurements)
SENSOR A and SENSOR B

REL (Relative Measurements)

Description

Relative mode permits any measurement result to be compared in dB or % to a reference value. Pressing the REL key enters or exits relative mode. Once relative mode has been entered, the first reading is saved as a reference value. Successive measurements are displayed relative to the reference value.

If a new measurement mode is selected while relative mode is enabled, REL is disabled and the reference value is lost.

Procedure

Press REL to toggle in and out of relative mode.

Press dBm/WATT to alternate between dB and percent.

Example

To enter relative mode and make relative measurements (assuming that the Power Meter is not in relative mode):

LOCAL (keystrokes)	REL
HP-IB (program codes)	RL1

Program Codes HP-IB

Parameter	Program Code
Enter REL mode	RL1
Exit REL mode	RL0

Indications

When the Power Meter is displaying a relative measurement, the REL annunciator on the front panel display lights. The displayed value is the measurement result relative to the reference in dB or %.

Comments

Relative measurements cannot be output via the rear panel RCDR output.

If the reference is zero or negative power, the measurement result can be displayed in dB as long as the measured power does not change signs (that is, positive to negative or vice versa) while REL mode is on. If the measured power does change signs while displaying dB in REL mode, Error 27 (illegal logarithmic operation) occurs.

If a negative reference is used, the ratio indication (%) will be displayed in absolute value.

The reference value is stored if the Power Meter is in REL mode when the instrument configuration is saved.

The reference value, once set, cannot be read.

Related Sections

dBm/WATT (Logarithmic/Linear Measurement Units)
SENSOR A and SENSOR B
SENSOR A–B and SENSOR B–A
SENSOR A/B and SENSOR B/A
STORE and RECALL

SENSOR A and SENSOR B

(Single Sensor Measurements)

Description SENSOR A and SENSOR B cause the Power Meter to make single sensor measurements. Absolute power is displayed for the selected sensor in either dBm or Watts. In addition, SENSOR A sets the active entry channel to A, and SENSOR B sets the active entry channel to B.

Procedure To select a single sensor measurement mode, press SENSOR A or SENSOR B.

Example To select SENSOR A as the measurement mode:

LOCAL (keystrokes)	Sensor → A
HP-IB (program codes)	AP → Sensor

Program Codes HP-IB

Parameter	Program Code
SENSOR A	AP
SENSOR B	BP

Indications The middle block of annunciators on the front panel display indicate the measurement mode and the measurement units. The cal factor and offset (if any) for the selected sensor are also indicated in the front panel display.

Comments Filter, range, offset, cal factor, and limits can be set for the selected sensor.

PRESET sets the measurement mode to SENSOR A.

Single sensor measurements can be displayed relative to a stored reference. In REL mode readings are dislayed in either dB or percent.

Changing the measurement mode causes the contents of the digital filter to be discarded.

Related Sections

CAL FACTOR
dBm/WATT (Logarithmic/Linear Units)
Filters
OFFSET
PRESET
Range
REL (Relative Measurements)
SET A and SET B
STORE and RECALL

SENSOR A – B AND SENSOR B – A

(Dual Sensor Difference Measurements)

Description

SENSOR A–B and SENSOR B–A cause the Power Meter to make dual sensor difference measurements. The Power Meter displays the numerical difference of the power values of both sensors. The power values for sensors A and B include all offsets and cal factors that have been set for each individual channel. Measurement results are displayed in either dBm or Watts. In addition, A–B sets A as the active entry channel, and B–A sets B as the active entry channel.

Procedure

To make a difference measurement, press the SHIFT key and then select A–B or B–A, as desired.

Example

To select B–A measurement mode:

LOCAL (keystrokes)	SHIFT B
HP-IB (program codes)	BD Sensor

Program Codes HP-IB

Parameter	Program Code
SENSOR A–B	AD
SENSOR B–A	BD

Indications

The middle block of annunciators on the front panel display indicate the measurement mode (either A–B or B–A) and the measurement units (either dBm or Watts).

Comments

Cal factor, offset, range, limits, and filter are set separately for each sensor.

Logarithmic units (dBm) cannot be used in A–B difference measurements where the sensor A power level is less than the sensor B power level. Likewise, logarithmic units cannot be used in B–A difference measurements where the sensor B power level is less than the sensor A power level.

Difference measurements can be displayed relative to a stored reference. In REL mode, readings are displayed in either dB or percent.

Changing the measurement mode causes the contents of the digital filter to be discarded. The filter buffer then starts filling up with values from the new measurement mode. The Power Meter displays the average of the accumulated readings.

SENSOR A – B AND SENSOR B – A (cont'd)

(Dual Sensor Difference Measurements)

Related Sections

Cal Factor
dBm/Watt (Logarithmic/Linear Measurement Units)
Filters
Limits
OFFSET
PRESET
Range
REL (Relative Measurements)
SET A and SET B
STORE and RECALL

SENSOR A/B and SENSOR B/A

(Dual Sensor Ratio Measurements)

Description SENSOR A/B and SENSOR B/A cause the Power Meter to make dual sensor ratio measurements. The Power Meter displays the ratio of the sensors' power values in either dB or percent. The power value of each sensor includes offsets and cal factors in addition to measured power. Also, A/B sets A as the active entry channel, and B/A sets B as the active entry channel.

Procedure To make B/A ratio measurements, press B/A. To make A/B ratio measurements, press the SHIFT key and then B/A.

Example To make B/A ratio measurements:

LOCAL (keystrokes)	B/A
HP-IB (program codes)	BR Sensor

Program Codes HP-IB

Parameter	Program Code
SENSOR A/B	AR
SENSOR B/A	BR

Indications The middle block of annunciators on the front panel display indicate the measurement mode (A/B or B/A) and the measurement units (dB or %).

Comments Cal factor, range, filter, limits, and offset are set separately for each sensor.

Ratio measurements can be displayed relative to a stored reference. In REL mode, readings are displayed in either dB or percent.

Changing the measurement mode causes the contents of the digital filter to be discarded. The filter buffer then starts filling up with values from the new measurement mode. The Power Meter displays the average of the accumulated readings.

Ratios where the denominator is equal to zero cause Error 27 (log error) to be displayed.

Logarithmic measurement units (dB) cannot be used if the ratio is negative. To do so would cause Error 27 (log error) to be displayed.

SENSOR A/B and SENSOR B/A (cont'd)

(Dual Sensor Ratio Measuremetns)

Related Sections

CAL FACTOR
dBm/WATT (Logarithmic/Linear Units)
Error Messages
Filters
Limits
OFFSET
Range
REL
SET A and SET B
STORE and RECALL

SET A and SET B

Description

SET A and SET B are used to select the channel on which measurement parameter changes are to be made. Measurement parameters consist of the following:

Cal Adj (reference calibration factor)	Offset
Cal Factor	Range
Filters	Zero
Limits	

SET A and SET B allow measurement parameters to be set for one channel while working in any measurement mode.

Selecting measurement mode SENSOR A, A–B, or A/B automatically sets the active entry channel to channel A. Selecting measurement mode SENSOR B, B–A, or B/A automatically sets the active entry channel to channel B.

Procedure

To select the active entry channel, press SET A for channel A or SET B for channel B.

Example

To designate channel B as the active entry channel:

LOCAL (keystrokes)	SET B
HP-IB (program codes)	BE

Program Codes HP-IB

Parameter	Program Code
SET A	AE
SET B	BE

Indications

When a measurement parameter is being entered, an annunciator on the right side of the display lights to indicate the active entry channel.

Comments

PRESET sets the active entry channel to A.

Related Sections

CAL ADJ	PRESET
Cal Factor	Range
Filters	SENSOR A and SENSOR B
Limits	SENSOR A–B and SENSOR B–A
OFFSET	SENSOR A/B and SENSOR B/A

STORE and RECALL

Description The Power Meter can store instrument configurations for recall at a later time. The following information can be stored in the Power Meter's internal registers:

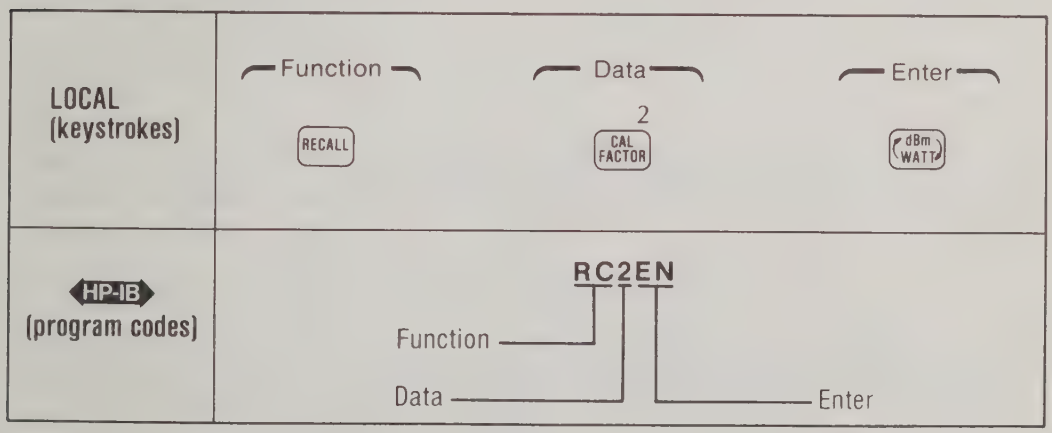
Measurement Mode
REL mode status (on or off)
Reference value if in REL mode
Reference Oscillator status (on or off)
Active entry channel (A or B)
Measurement units (logarithmic or linear)
Cal factor for each sensor
Offset for each sensor
Range for each sensor
Filter for each sensor
Cal Adj value for each sensor

Registers 1 through 19 are available for storing instrument configurations. Registers 0 through 19 are available for recall. Register 0 always contains the previous Power Meter configuration. Thus, RECALL 0 provides a way to recover from an entry error.

Procedure To store an instrument configuration, press STORE, enter a number from 1 to 19, and then press ENTER.

To recall an instrument configuration, press RECALL, enter a number from 0 to 19, and then press ENTER.

Example To recall an instrument configuration that has been stored in register 2:



Program Codes HP-IB

Parameter	Program Code
RECALL	RC
STORE	ST
ENTER	EN

Indications When the stored contents of a register are recalled, the Power Meter changes to the recalled parameter values.

STORE and RECALL (cont'd)

Comments

The Power Meter executes a RECALL 0 at power-up. This places the Power Meter in the same state that it was in when power was removed.

The Cal Adj value (reference calibration factor) for each sensor can be stored and recalled but the internal calibration settings are not stored.

PRESET has no effect on the storage registers 1 through 19. Register 0, however, is set to the PRESET conditions when the PRESET key is pressed.

Storage register 0 is set to the PRESET state when a continuous memory error (Error 57) occurs.

High and low limits cannot be stored.

Procedure cont'd

CAL ADJ
CAL FACTOR
dBm/WATT (Logarithmic/Linear Units)
Error Messages
Filters
Limits
OFFSET
PRESET
Range
REL (Relative Measurements)
SET A and SET B

ZERO

Description ZERO is used to adjust the Power Meter's internal circuitry for a 0 power indication when no power is applied to the sensor. Pressing the ZERO key automatically zeroes all five of the Power Meter's ranges. For dual sensor measurements, each channel of the Power Meter must be zeroed separately.

NOTE

Be sure that no power is applied to the sensor while the Power Meter is zeroing. Any applied RF input power introduces an offset that affects all subsequent measurements.

Procedure To zero the Power Meter to the sensor connected to the active entry channel, press ZERO.

Example To zero the Power Meter:

LOCAL (keystrokes)	ZERO
HP-IB (program codes)	ZE

Program Codes HP-IB

The program code for ZERO is ZE.

Indications The Power Meter display shows eight dashes and a moving decimal point while zeroing. When the zeroing is completed, new zero values are stored and the instrument is returned to its previous state.

Comments Zero the Power Meter before entering the reference calibration factor.

The Power Meter's internal reference oscillator automatically turns off during zeroing. If the reference oscillator was on before the zeroing was initiated it will be returned to the on state when zeroing is completed.

To determine whether or not the Power Meter needs to be zeroed, remove any power to the sensor and then read the front panel display. If the display does not indicate 0 power, the Power Meter needs to be zeroed. Any residual nonzero reading, if not corrected, will be added to all subsequent measurements, resulting in an error. This error may be insignificant when measuring moderate to high power values, but it can be unacceptable when measuring low power values.

Error 57 (recall fail) occurs when the Power Meter is turned on and the internal RAM contents have been lost. This is generally due to battery failure but may also occur when the instrument is powered down while zeroing.

ZERO (cont'd)

Procedure cont'd

For best accuracy, HP 8484A Power Sensors should be connected to a device with the RF power off before zeroing.

Zeroing data cannot be stored and recalled, but it is remembered when the instrument is turned off.

PLEASE 0 (Error 15 or 16, sensor dependent)) is displayed when the zero reference drifts negative.

Related Sections

CAL ADJ
Error Messages
Range
STORE and RECALL

SECTION IV
PERFORMANCE TESTS

4-1. INTRODUCTION

The procedures in this section test the instrument's electrical performance using the specifications of Table 1-1 as the performance standards. All tests can be performed without access to the interior of the instrument. A simpler operational test is included in Section III under Basic Functional Checks.

NOTE

If the performance tests are to be considered valid, the following conditions must be met:

a. The Power Meter must have a 1 hour warm-up for all specifications.

b. The line voltage for all instruments must be 100, 120, 220, or 240 Vac +5%, -10%; and the line frequency must be 48 to 66 Hz. The Power Meter has the additional capability of operating on line frequencies of 360 to 440 Hz, but the line voltage is limited to a nominal 100 or 120 Vac.

c. The ambient temperature must be 0°C to 55°C.

4-2. EQUIPMENT REQUIRED

Equipment required for the performance tests is listed in Table 1-3, Recommended Test Equipment. Any equipment that satisfies the critical specifications given in the table may be substituted.

4-3. PERFORMANCE TEST RECORD

Results of the performance test may be tabulated in Table 4-1, Performance Test Record. The Performance Test Record lists all of the performance test specifications and the acceptable limits for each specification. If performance test results are recorded during an incoming inspection of the instrument, they can be used for comparison during periodic maintenance or troubleshooting procedures. The test results may also prove useful in verifying proper adjustments after repairs are made.

4-4. PERFORMANCE TESTS

The performance tests given in this section are suitable for incoming inspection, troubleshooting, or preventive maintenance. During any performance test, all shields and connecting hardware must be in place. The tests are designed to verify published instrument specifications. Perform the tests in the order given and record the data on the test card and/or in the data spaces provided at the end of each procedure.

4-5. CALIBRATION CYCLE

This instrument requires periodic verification of performance to ensure that it is operating within specified tolerances. The performance tests described in this section should be performed at least once each year; under conditions of heavy usage or severe operating environments, the tests should be more frequent. Adjustments that may be required are described in Section V, Adjustments.

4-6. ABBREVIATED PERFORMANCE TEST

Refer to Section III, Operation, for a Basic Functional Checks test.

4-7. TEST PROCEDURES

It is assumed that the person performing the following tests understands how to operate the specified test equipment. Equipment settings, other than those for the Power Meter, are stated in general terms. It is also assumed that the technician will select the power sensor, cables, adapters and probes required for test setups illustrated in this section.

PERFORMANCE TESTS

4-8. ZERO CARRYOVER TEST

Specification

Electrical Characteristics	Performance Limits	Conditions
ACCURACY Zero set (Digital settability of zero)	±0.5% full scale	Most sensitive range. Decrease percentage by factor of 10 for each higher range ±1 count.

Description

After the Power Meter is initially zeroed, the change in the digital readout is monitored as the Power Meter is stepped through its ranges. This test also takes drift and noise into account, since drift, noise and zero carryover readings cannot be separated.

Figure 4-1. Zero Carryover Test Setup

Equipment

Range Calibrator ..... HP 11683A
Power Sensor Cable ..... HP 11730A

Procedure

1. Connect the equipment as shown in Figure 4-1.

2. Set the Power Meter controls as follows:

   LINE ..... ON
   PRESS ..... PRESET

3. Set the range calibrator switches as follows:

   FUNCTION ..... STANDBY
   LINE ..... ON

4. Press the Power Meter's ZERO switch and wait (approximately 15 to 17 seconds) for the display to reappear and stabilize. Verify that the reading is 0.00 ±0.06.

NOTE

The Power Meter is now zeroed on range 1 (most sensitive).

5. Press MNL RANGE, then 1, then ENTER.

PERFORMANCE TESTS

4-8. ZERO CARRYOVER TEST (cont'd)

Procedure (cont'd)

6. After the Power Meter reading has stabilized, verify that the indication is within the limits shown.

Power Meter Range	Results			
	Min	Actual		Max
		A	B	
1	−0.06 μW	_____	_____	0.06 μW
2	−0.1 μW	_____	_____	0.1 μW
3	−0.001 mW	_____	_____	0.001 mW
4	−0.01 mW	_____	_____	0.01 mW
5	−0.1 mW	_____	_____	0.1 mW

7. Repeat steps 5 and 6 by entering 2, then 3, then 4, and 5.

8. Repeat steps 2 through 7 for Channel B by pressing B in Step 2.

9. Repeat steps 2 through 7 for Channel A and B when rear panel Option 002 inputs are installed.

PERFORMANCE TESTS

4-9. INSTRUMENT ACCURACY TEST

Specification

Electrical Characteristics	Performance Limits	Conditions
ACCURACY		
Instrumentation includes sensor linearity		
Single channel mode	±0.02 dB	Within same calibration range
	Plus ±0.02 dB	Outside calibration range
Dual channel mode (Ratio or difference)	Multiply single channel specifications by 2	

Description

After the Power Meter is initially calibrated on the 1 mW range, the readout is monitored as the range calibrator is switched to provide reference inputs corresponding to each of the Power Meter operating ranges.

Figure 4-2. Instrument Accuracy Test Setup

Equipment

Range Calibrator ..... HP 11683A
Power Sensor Cable ..... HP 11730A

Procedure

1. Connect the equipment as shown in Figure 4-2.

2. Set the Power Meter controls as follows:

LINE ..... ON
SENSOR ..... A
PRESS ..... PRESET

3. Set the range calibrator switches as follows:

FUNCTION ..... STANDBY
POLARITY ..... NORMAL
RANGE ..... 1 mW
LINE ..... ON

PERFORMANCE TESTS

4-9. INSTRUMENT ACCURACY TEST (cont'd)

Procedure (cont'd)

4. Press the Power Meter ZERO key, and wait for the readout to reappear. Verify that the reading is 0.00 ± 0.06 μW.

5. Set the range calibrator FUNCTION switch to CALIBRATE.

6. Press Power Meter CAL ADJ key, then press ± key to get minus (−) sign, then press 100 ENTER. The minus sign indicates use of an external reference source. If the minus sign is not used there will be a NO REF error on the display.

7. Verify that the Power Meter display reads 1.000 ±0.006 mW.

NOTE

The range calibrator output level is adjustable in 5 dB increments. Thus, the 3 μW, 30 μW, 300 μW, 3 mW, and 30 mW legends on the RANGE switch are approximations. The true values for these settings are 3.16, 31.6, and 316 μW, 3.16 mW and 31.6 mW.

8. Set the range calibrator RANGE switch to the 10 μW position, and then to the 100 μW, 10 mW and 100 mW positions. For each setting, verify that the Power Meter autoranges properly, and that the display is within the limits shown.

Range Calibrator Range	Results		
	Min	Actual	Max
10 μW	9.90 μW	_____	10.10 μW
100 μW	99.0μW	_____	101.0 μW
1 mW	0.995 mW	_____	1.005 mW
10 mW	9.90 mW	_____	10.10 mW
100 mW	99.0 mW	_____	101.0 mW

9. Press the Power Meter channel B key and repeat steps 4 through 6 to test channel B.

10. Set the Power Meter dBm/WATT switch to the dBm position and verify that the display changes to the dBm mode, and that the indication is within 20.00 ± 0.02 dBm. It is not necessary to check all ranges in both modes since the same circuitry is used to measure power and only a conversion is performed.

19.98 dBm _____ 20.02 dBm

11. Set the range calibrator RANGE switch to -10 dBm.

12. Verify that the Power Meter displays -10.00 ±0.02 dBm.

-9.98 dBm _____ -10.02 dBm

13. Press the Power Meter REL key and verify that the display indicates 0.00 ±0.01 dB.

PERFORMANCE TESTS

4-10. POWER REFERENCE LEVEL TEST

Specification

Electrical Characteristics	Performance Limits	Conditions
Power reference	1.00 mW	Internal 50 MHz oscillator factory set to ±0.7% traceable to National Bureau of Standards
Power Reference Accuracy	±1.2%	
	±0.9%	Worst case RSS for one year

Description

The power reference oscillator output is factory adjusted to 1 mW ±0.7%. To achieve this accuracy, Hewlett-Packard employs a special measurement system accurate to 0.5% (traceable to the National Bureau of Standards) and allows for a transfer error of ± 0.2% in making the adjustment. If an equivalent measurement system is employed for verification, the power reference oscillator output can be verified to 1 mW ±1.9% (±1.2% accuracy plus ±0.5% verification system error plus ±0.2% transfer error =1.9% maximum error). The power reference oscillator can be set to ±0.7% using the same equipment and following the adjustment procedure. To ensure maximum accuracy in verifying the power reference oscillator output, the following procedure provides step by step instructions for using specified Hewlett-Packard test instruments of known capability. If equivalent test instruments are used, signal acquisition criteria may vary and reference should be made to the manufacturer's guidelines for operating the instruments.

NOTE

The Power Meter may be returned to the nearest Hewlett-Packard office to have the power reference oscillator checked and/or adjusted. Refer to Section II, Packaging.

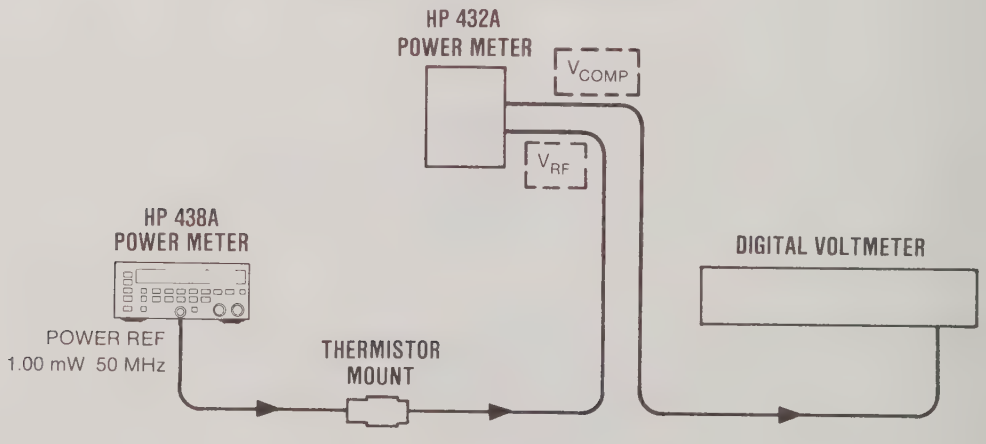


Figure 4-3. Power Reference Level Test Setup

PERFORMANCE TESTS

4-10. POWER REFERENCE LEVEL TEST (cont'd)

Equipment

Test Power Meter	HP 432A
Thermistor Mount	HP 478A-H75
Digital Voltmeter (DVM)	HP 3456A

Procedure

1. Set up the DVM to measure resistance and connect the DVM between the Vrf connector on the rear panel of the test power meter, and pin 1 on the thermistor mount end of the test power meter interconnect cable.

2. Round off the DVM indication to two decimal places and record this value as the internal bridge resistance (R) of the test power meter (approximately 200 ohms).

   R _____

3. Connect the test power meter to the Power Meter as shown in Figure 4-3.

4. Set the Power Meter LINE switch to ON and the OSC switch off (LED off). Then wait thirty minutes for the test power meter thermistor mount to stabilize before proceeding to the next step.

5. Set the test power meter Range switch to Coarse Zero and adjust the front panel Coarse Zero control to obtain a zero meter indication.

6. Fine Zero the test power meter on the most sensitive range, then set the test power meter Range switch to 1 mW.

NOTE

Ensure that DVM input leads are isolated from chassis ground when performing the next step.

7. Set up the DVM to measure microvolts and connect the positive and negative input leads, respectively, to the Vcomp and Vrf connectors on the rear panel of the test power meter.

8. Observe the indicaion on the DVM. If less than 400 microvolts, proceed to the next step. If 400 microvolts or greater, press and hold the test power meter Fine Zero switch and adjust the Coarse Zero control so that the DVM indicates 200 microvolts or less. Then release the Fine Zero switch and proceed to the next step.

9. Round off the DVM indication to the nearest microvolt and record this value as V_0.

   V_0 _____

10. Set the Power Meter OSC switch to ON (LED on) and record the indications observed on the DVM as V_1.

    V_1 _____

PERFORMANCE TESTS

4-10. POWER REFERENCE LEVEL TEST (cont'd)

Procedure (cont'd)

11. Disconnect the DVM negative input lead from the Vrf connector on the test power meter and reconnect it to test power meter chassis ground. Record the new indication observed on the DVM as Vcomp.

V_{comp} _____

12. Calculate the power reference oscillator output level (Prf) from the following formula:

$$Prf = \frac{2V_{comp}(V_1 - V_0) + V_0^2 - V_1^2}{4R\,(\text{Calibration Factor})}$$

Where:

Prf = power reference oscillator output level
V_{comp} = previously recorded value
V1 = previously recorded value
V0 = previously recorded value
R = previously recorded value

Calibration Factor = value for thermistor mount at 50 MHz (traceable to the National Bureau of Standards).

13. Verify that the Prf is within the following limits:

Min	Actual	Max
0.988 mW	_____	1.012 mW

Table 4-1. Performance Test Record

Hewlett-Packard Company
Model HP 438A
Power Meter
Serial Number _____ Tested by _____
Date _____

Para. No.	Test	Minimum	Results Actual	Maximum
4-8.	**ZERO CARRYOVER**			
	Power Meter Range			
	1	−0.06 μW	_____	10.06 μW
	2	−0.1μW	_____	0.1 μW
	3	−0.001 mW	_____	0.001 mW
	4	−0.01 mW	_____	0.01 mW
	5	−0.1 mW	_____	0.1 mW
4-9.	**INSTRUMENT**			
	Accuracy			
	Watt Mode			
	10 μW	9.90μW	_____	10.10 μW
	100 μW	99.0μW	_____	101.0 μW
	1 mW	0.995 mW	_____	1.005 mW
	10 mW	9.90 mW	_____	10.10 mW
	100 mW	99.0 mW	_____	101.0 mW
	dBm Mode			
	20 dBm	19.98 dBm	_____	20.02 dBm
4-10.	**POWER REFERENCE**			
	Prf	0.988 mW	_____	1.012 mW

SECTION V
ADJUSTMENTS

5-1. INTRODUCTION

This section contains adjustments and checks that ensure proper performance of the Power Meter. Adjustments are not required on any fixed periodic basis, and normally are performed only after a performance test has indicated that some parameters are out of specification. Performance tests should be completed after any repairs that may have altered the characteristics of the instrument. The test results will make it possible to determine whether or not adjustments are required. Allow 60 minutes for the Power Meter to warm up, and then remove the top and bottom covers, also loosen the screws holding the A3 CPU Assembly and A5 Main Amplifier Assembly for access to the test and adjustment points.

To determine which performance tests and adjustments to perform after a repair, refer to paragraph 5-6, Post-Repair Tests, Adjustments, and Checks.

5-2. SAFETY CONSIDERATIONS

This section contains a warning that must be followed for your protection and to avoid damage to the equipment being used.

WARNING

Adjustments described in this section are performed with power applied to the instrument and with protective covers removed. Maintenance should be performed only by trained personnel who are aware of the hazards involved. When the maintenance procedure can be performed without power, the power should be removed.

5-3. EQUIPMENT REQUIRED

Most of the adjustment procedures include a list of recommended test equipment, and the test equipment is also identified on the test setup diagrams. If substitutions must be made, the equipment used must meet the critical specification listed in Table 1-3 in Section I.

5-4. FACTORY SELECTED COMPONENTS

Factory selected components are identified on the schematics and parts lists by an asterisk(*) which follows the reference designator. The nominal value of the selected component is shown. Table 5-1 lists the reference designator, the service sheet where the component is shown, the value range, and the basis for selecting a particular value.

5-5. INTERRELATED ADJUSTMENTS

The −15V adjustment on the A9 Regulator Assembly should be the first item checked during any adjustment procedure. The −15V source and the +15V source are such that they are equal but opposite in sign. The +5V (D) digital is measured and adjusted second before the other adjustment procedures are started.

NOTE

Make adjustments only in the order specified.

5-6. POST-REPAIR ADJUSTMENTS

Table 5-2 lists the adjustments related to repairs or replacement of any of the assemblies.

Table 5-1. Factory Selected Components

Reference Designator	Service Sheet	Range of Values	Basis of Selection
G1A1R2 G1A1VR2 combination (G2A1R2 G2A1VR2 option 002)	11	825Ω with 5.11V Zener or 1470Ω with 8.25V Zener	1. If the reference power is outside the range of 1.000±0.007 mW between 0°C and 55°C, and if the G1A1R2, G1A1VR2 combination is 825Ω 5.11V then change the G1A1R2, G1A1VR2 combination to 1470Ω 8.25V. However, if the G1A1R2, G1A1VR2 combination is already 1470Ω 8.25V, then a problem exists elsewhere.

Table 5-2. Post-Repair Adjustments, Tests, and Checks

Assembly Repaired	Related Adjustment or Performance Test	Reference Service Sheet
A1 Keyboard	None	1
A2 Display	None	5
A3 Central Processing Unit	5-7, 5-8, 5-9	1,2,3,4
A4 Input Amplifier	5-7, 5-8, 5-10, 5-11	6
A5 Main Amplifier	5-7, 5-8, 5-9	7,8
A8 Rectifier	4-10, 4-11, 4-12, 4-13, 5-7, 5-8	9
A9 Regulator	4-8, 4-9, 5-7, 5-8	9,10
G1 50 MHz Reference Oscillator	5-7, 5-8, 5-12, 5-13	11

ADJUSTMENTS

5-7. ±15 VOLT POWER SUPPLY ADJUSTMENT

Reference Service Sheet 10

Description The +15 volt supply is measured, then the −15 volt supply is measured and adjusted so that the supplies are equal in amplitude but of opposite sign.

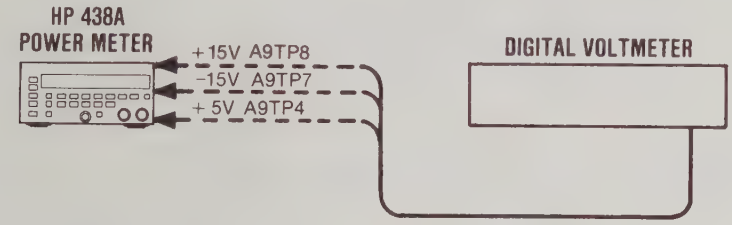


Figure 5-1. Power Supply Adjustments Setup

Equipment Digital Voltmeter (DVM) ..... HP 3456A

Procedure

1. Remove the top and bottom covers of the Power Meter. Loosen screws that secure the A3 CPU Assembly. Turn the instrument on and allow for the warm-up.

2. Connect the DVM between the +15V testpoint A9TP8 and chassis ground. Measure and record the value of the +15 volts. The voltage should be between 14.25 and 15.75 Vdc.

   +14.923

   +15V _____

3. Connect the DVM between the −15V testpoint A9TP7 and chassis ground. Adjust −15V, A9R16, until the DVM reading is within 0.05 Vdc of the numerical value from step 2. Ignore the difference in sign for this adjustment.

ADJUSTMENTS

5-8. +5 VOLT POWER SUPPLY ADJUSTMENT

Reference Service Sheet 9

Description The +5 volt supply is measured and adjusted.

Equipment Digital Voltmeter (DVM) ..... HP 3456A

Procedure

1. See Figure 5-1. Connect the DVM between the +5V testpoint A9TP4 and ground. Adjust +5V, A9R3 to 5.00 ± 0.05 volts as read on the DVM.

ADJUSTMENTS

5-9. ANALOG TO DIGITAL CONVERTER SLOPE ADJUSTMENT

Reference Service Sheet 8

Description The Analog to Digital Converter is adjusted for a central reading.

Figure 5-2. Analog to Digital Converter Slope Adjustment Setup

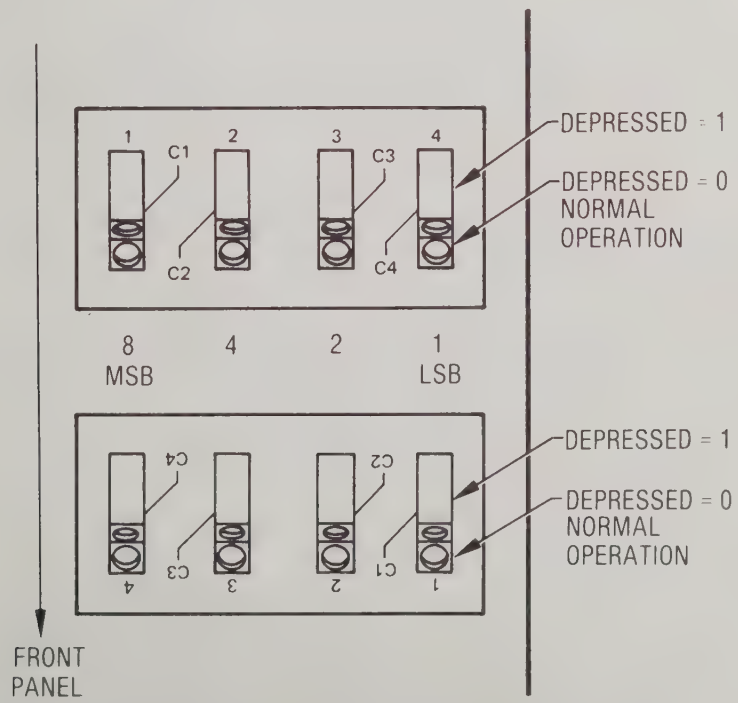
Equipment Digital Voltmeter (DVM) ..... HP 3456A

Procedure

1. Turn the Power Meter off. Place all 4 switches of A3S1 to the test position. This would be positions where the switches are all opposite to the normal operating position.

NOTE

A3S1 can be loaded on the printed circuit board so that it has one of the two orientations shown.



ADJUSTMENTS

5-9. ANALOG TO DIGITAL CONVERTER SLOPE ADJUSTMENT (cont'd)

2. Turn the Power Meter on. The instrument should now display — — — — — . Connect the digital DVM between B-GND A5TP2 and +2.5V REF A5TP8 test-points on A5. Read the DVM.

_____

3. Enter the reading to 5 digits (4 decimal places) into the Power Meter by entering the numbers into the keyboard, then pressing ENTER.

4. Adjust the ADC SLOPE, A5R61, so that the display reading is centered about zero. (The reading may be from +5.00 to -5.00, try to get as close to zero as possible.)

5. Turn off the Power Meter. Return A3S1 to its original position.

ADJUSTMENTS

5-10. 220 Hz FREQUENCY ADJUSTMENT

Reference Service Sheet 6

Description The 220 Hz is adjusted for maximum Power Meter readout.

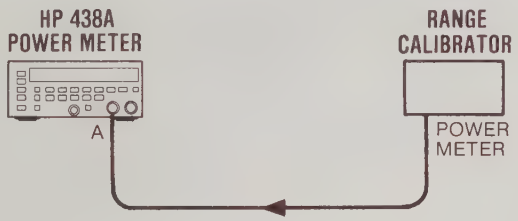


Figure 5-3. 220 Hz Frequency Adjustment Setup

Equipment Range Calibrator ..... HP 11683A

Procedure

1. Turn on both the Power Meter and the range calibrator. Set the range calibrator controls as follows:

   LINE ..... ON
   RANGE ..... 1 mW
   FUNCTION ..... STANDBY
   POLARITY ..... NORMAL

2. Connect the range calibrator output to channel A using the sensor cable. Press PRESET on the Power Meter then press ZERO, and allow time (approximately 15 to 17 seconds) for the Power Meter zeroing process.

3. Set the range calibrator function switch to calibrate.

4. On the Power Meter press CAL ADJ, (−), 100, then ENTER. This procedure allows the Power Meter to calibrate using an external reference, the range calibrator output.

5. Adjust 220 Hz, A4R43, for the maximum front panel reading.

ADJUSTMENTS

5-11. RANGES 4 and 5 SHAPER ADJUSTMENT, CHANNEL A AND B

Reference Service Sheet 6

Description Ranges 4 and 5 Shaper circuits are adjusted for proper gain.

Figure 5-4. Ranges 4 and 5 Shaper Adjustment Setup

Equipment Range Calibrator ..... HP 11683A

Procedure

1. Connect range calibrator to channel A input connector.
2. Set the range calibrator controls as follows:

   LINE ..... ON
   RANGE ..... 1 mW
   FUNCTION ..... STANDBY
   POLARITY ..... NORMAL

3. Turn on the Power Meter, and press PRESET. After zeroing the Power Meter, set the range calibrator to calibrate, then press CAL ADJ, (-), 100, and ENTER on the Power Meter.
4. Set the range calibrator range to 10 mW.
5. Adjust RNG 4, A4R26, for a reading of 10.00 ±0.01 mW on the Power Meter display.
6. Set the range calibrator range to 100 mW.
7. Adjust RNG 5, A4R34, for a reading of 100.0 ±0.1 mW on the Power Meter display.
8. Repeat steps 5 through 7 to check that interaction between steps has not caused a shift in settings.
9. Repeat the procedure for channel B of the Power Meter by making connection to channel B from the range calibrator.
10. Repeat the above procedure, starting with step 3, except press B on the Power Meter. Adjust RNG 4 SHP, A4R27, and RNG 5 SHP, A4R35, as in steps 5 and 7 above.

ADJUSTMENTS

5-12. POWER REFERENCE OSCILLATOR FREQUENCY ADJUSTMENT

NOTE

Adjustment of the Power Reference Oscillator frequency may also affect the output level of the oscillator. Thus after the frequency is adjusted 50.0 ±0.5 MHz, the output level should be checked as described in Section IV. A procedure for adjusting the output to the specified level is provided in the next paragraph.

Reference Service Sheet 11

Description Variable inductor G1A1L1 is adjusted to set the power reference oscillator output frequency to 50.0 ±0.5 MHz.

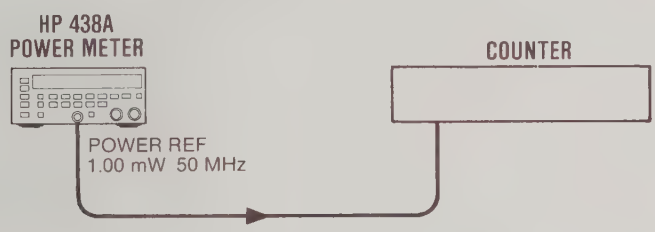


Figure 5-5. Power Reference Oscillator Frequency Adjustment Setup

Equipment Frequency Counter ..... HP 5328A Option 031

Procedure

1. Connect the equipment as shown in Figure 5-5 and set up the counter to measure frequency.
2. Set the Power Meter LINE switch to ON (in) and the POWER REF OSC switch to OFF (LED off).
3. Set the Power Meter POWER REF OSC switch to ON (LED on) and observe the indication on the counter. If it is 50.0 ± 0.5 MHz, no adjustment of the power reference oscillator frequency is necessary. If it is not within these limits, adjust the power reference oscillator frequency as described in steps 4 and 5.
4. Remove the Power Meter top cover, and loosen screws holding the A3 CPU Assembly. Swing out the assembly and the screwdriver adjustment is accessible through a hole in the deck.
5. Adjust G1A1L1 to obtain a 50.00 ± 0.5 MHz indication on the counter.

ADJUSTMENTS

5-13. POWER REFERENCE OSCILLATOR LEVEL ADJUSTMENT

Reference Service Sheet 11

Description The power reference oscillator is factory-adjusted to 1.0 mW ± 0.7% using a special measurement system accurate to 0.5% (traceable to the National Bureau of Standards) and allowing for a 0.2% transfer error. To ensure maximum accuracy in readjusting the power reference oscillator, the following procedure provides step-by-step instructions for using specified Hewlett-Packard instruments of known capability. If equivalent instruments are used, signal acquisition criteria may vary and reference should be made to the manufacturer's guidelines for operating the equipment.

NOTE

The Power Meter may be returned to the nearest HP office to have the power reference oscillator checked and/or adjusted. Refer to Section II PACKAGING

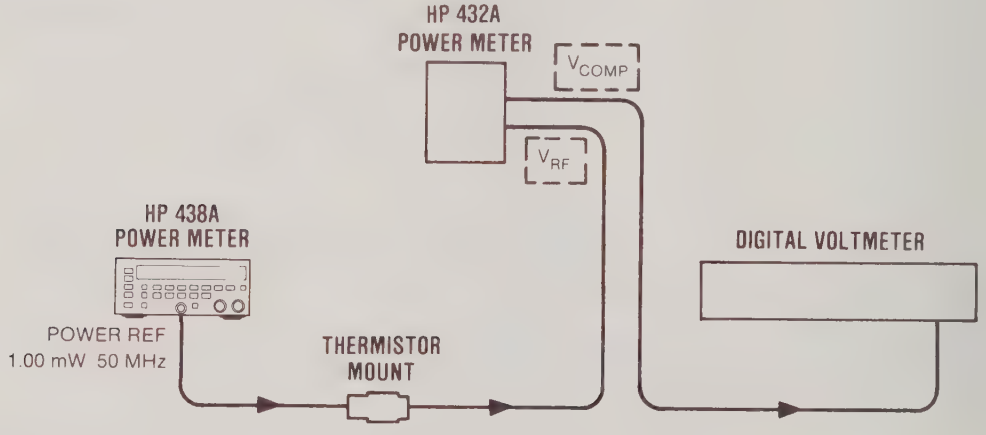


Figure 5-6. Power Reference Oscillator Level Adjustment Setup

Equipment

Test Power Meter	HP 432A
Thermistor Mount	HP 478A-H75
Digital Voltmeter (DVM)	HP 3456A

Procedure

1. Set up the DVM to measure resistance and connect the DVM between the Vrf connector on the rear panel of the test power meter and pin 1 on the thermistor mount end of the test power meter interconnect cable.

ADJUSTMENTS

5-13. POWER REFERENCE OSCILLATOR LEVEL ADJUSTMENT (cont'd)

Procedure (cont'd)

2. Round off the DVM indication to two decimal places and record this value as the internal bridge resistance (R) of the test power meter (approximately 200 ohms).

R (Internal Bridge Resistance) _____

3. Connect the test power meter to the Power Meter as shown in Figure 5-5.

4. Set the Power Meter LINE switch to ON and the POWER REF OSC switch off. Wait thirty minutes for the test power meter thermistor mount to stabilize before proceeding to the next step.

5. Set the test power meter range switch to coarse zero and adjust the front panel coarse zero control to obtain a zero meter indication.

6. Fine zero the test power meter on the most sensitive range, then set the test power meter range switch to 1 mW.

NOTE

Ensure that the DVM input leads are isolated from chassis ground when performing the next step.

7. Set up the DVM to measure microvolts and connect the positive and negative input leads, respectively, to the Vcomp and Vrf connectors on the rear panel of the test power meter.

8. Observe the indication on the DVM. If less than 400 microvolts, proceed to the next step. If 400 microvolts or greater, press and hold the test power meter fine zero switch and adjust the coarse zero control so that the DVM indicates 200 microvolts or less. Then release the fine zero switch and proceed to the next step.

9. Round off the DVM indication to the nearest microvolt and record this value as V_0.

V_0 _____

10. Disconnect the DVM negative input lead from the Vrf connector on the test power meter and reconnect it to chassis ground.

11. Set the Power Meter POWER REF OSC on and record the indication observed on the DVM as V_{comp}.

V_{comp} _____

12. Disconnect the DVM negative input lead from chassis ground and reconnect it to the Vrf connector on the rear panel of the test power meter. The DVM is now set up to measure V_1 which represents the power reference oscillator output level.

13. Calculate the value of V_1 equal to 1 mW from the following equation:

5-13. POWER REFERENCE OSCILLATOR LEVEL ADJUSTMENT (cont'd)

$$V_1 - V_0 = V_{COMP} - \sqrt{(V_{COMP})^2 - (10^{-3})(4R)(\text{EFFECTIVE EFFICIENCY})}$$

where:

V_0 = previously recorded value

V_{COMP} = previously recorded value

10^{-3} = 1 milliwatt

R = previously recorded value

EFFECTIVE EFFICIENCY = value for thermistor mount at 50 MHz (traceable to the National Bureau of Standards).

14. Remove the Power Meter top cover and adjust LEVEL ADJUST potentiometer G1A1R4 so that the DVM indicates the calculated value of V_1.

TYPICAL CALCULATIONS:

1. ACCURACY:

DVM Measurements:	(V_{COMP})	±0.018%
	$(V_1 - V_0)$	±0.023%
	(R)	±0.03%
Math Assumptions :		±0.01%
EFFECTIVE EFFICIENCY CAL (NBS):		±0.5%
MISMATCH UNCERTAINTY : (Source & Mount SWR ≤1.05)		±0.1%
		≤ ±0.7%

2. MATH ASSUMPTIONS:

$$P_{RF} = \frac{2V_{COMP}(V_1 - V_0) + V_0^2 - V_1^2}{(4R)(\text{EFFECTIVE EFFICIENCY})}$$

Assume: $V_0^2 - V_1^2 = (V_1 - V_0)^2$

$-(V_1 - V_0)^2 = -V_1^2 + 2V_1 - V_0^2$

Want: $V_0^2 - V_1^2$

$\therefore$ error = $(V_1^2 + 2V_1 V_0 - V_0^2) - (V_0^2 - V_1^2) = -2V_0^2 + 2V_1 V_0 = 2V_0(V_1 - V_0)$

if $2V_0(V_1 - V_0) << 2V_{COMP}(V_1 - V_0)$ i.e., $V_0 << V_{COMP}$, error is negligible.

$V_{COMP} \sim 4$ volts. If $V_0 < 400\ \mu V$, error is $< 0.01\%$.

(typically V_0 can be set to $< 50\ \mu V$).

5-13. POWER REFERENCE OSCILLATOR LEVEL ADJUSTMENT (cont'd)

TYPICAL CALCULATIONS (cont'd)

3. Derivation of Formula for $V_1 - V_0$

$$P_{RF} = \frac{2V_{COMP}(V_1 - V_0) + V_0^2 - V_1^2}{(4R)(\text{EFFECTIVE EFFICIENCY})}$$

Desired $P_{RF} = 1\ \text{mW} = 10^{-3}$

$$\therefore 10^{-3} = \frac{2V_{COMP}(V_1 - V_0) + V_0^2 - V_1^2}{(4R)(\text{EFFECTIVE EFFICIENCY})}$$

Let (4R) (EFFECTIVE EFFICIENCY) $(10^{-3}) = K$

Substitute $-(V_1 - V_0)^2$ for $V_0^2 - V_1^2$ (see Math Assumptions under Accuracy)

Then $0 = (V_1 - V_0)^2 - 2V_{COMP}(V_1 - V_0) + K$

or $V_1 - V_0 = V_{COMP} - \sqrt{(V_{COMP})^2 - K}$

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION

This section contains information for ordering parts. Table 6-1 lists part numbers for restored assemblies. Table 6-2 lists abbreviations used in the parts list and throughout the manual. Table 6-3 lists all replaceable parts in reference designator order. Table 6-4 contains the names and addresses that correspond to the manufacturer's code numbers.

6-2. ABBREVIATIONS

Table 6-2 lists abbreviations used in the parts list, schematics, and throughout the manual. In some cases, two forms of the abbreviation are used, one all in capital letters, and one partial or no capitals. This occurs because the abbreviations in the parts list are always all capitals. However, in the schematics and other parts of the manual, other abbreviation forms are used with both lower case and upper case letters.

6-3. REPLACEABLE PARTS LIST

Table 6-3 is the list of replaceable parts and is organized as follows:

a. Electrical assemblies and their components in alphanumeric order by reference designation.

b. Chassis-mounted parts in alphanumeric order by reference designation.

c. Mechanical parts.

The information given for each part consists of the following:

a. The Hewlett-Packard part number.

b. Part number check digit (CD).

c. Total quantity (Qty) used in the instrument.

d. Part description.

e. Five-digit code that represents a typical manufacturer.

f. Manufacturers part number.

NOTE

The total quantity for each part is given only once, that is, at the first occurrence of the part number in the list. The total quantities for optional assemblies are totalled by assembly and not integrated into the standard list.

6-4. FACTORY SELECTED PARTS (*)

Parts marked with an asterisk (*) are factory selected parts. The value listed in the parts list is the nominal value. Refer to Sections V and VIII of this manual for information on determining what value to use for replacement.

6-5. PARTS LIST BACKDATING (†)

Parts marked with a dagger (†) are different in Power Meters with serial number prefixes lower than the one that this manual applies to directly.

6-6. PARTS LIST UPDATING (Change Sheet)

Production changes to Power Meters made after the publication date of this manual are accompanied by a change in the serial number prefix. Changes to the parts list are recorded by serial number prefix on a MANUAL CHANGES supplement. Also, parts list errors are noted in the ERRATA portion of the MANUAL CHANGES supplement.

6-7. ILLUSTRATED PARTS BREAKDOWN

Most mechanical parts are identified in Figures 6-1 through 6-3. These figures are located at the end of the replaceable parts table.

6-8. ORDERING INFORMATION

To order a part listed in the replaceable parts table, include the Hewlett-Packard part number (with the check digit), and the quantity required. Address the order to the nearest Hewlett-Packard office. The check digit will ensure accurate and timely processing of your order.

To order a part that is not listed in the replaceable parts table, include the instrument model number,

ORDERING INFORMATION (cont'd)
instrument serial number, description and function of the part, and the number of parts required. Address the order to the nearest Hewlett-Packard office.

NOTE

Within the USA, it is better to order directly from the HP Parts Center in Mountain View, California. Ask your nearest HP office for information and forms for the "Direct Mail Order System".

6-9. RECOMMENDED SPARES LIST

Stocking spare parts for an instrument is often done to ensure quick return to service after a malfunction occurs. Hewlett-Packard prepares a "Recommended Spares" list for this instrument. The contents of the list are based on failure reports and repair data. Quantities given are for one year of parts support. A complimentary copy of the "Recommended Spares" list may be requested from your nearest Hewlett-Packard office.

When stocking parts to support more than one Signal Generator or to support a variety of Hewlett-Packard instruments, it may be more economical to work from one consolidated list rather than simply adding together stocking quantities from the individual instrument lists. Hewlett-Packard will prepare consolidated "Recommended Spares" lists for any number or combination of instruments. Contact your nearest Hewlett-Packard office for details.

6-10. RESTORED ASSEMBLIES

Table 6-1 lists assemblies within the instrument that may be replaced on an exchange basis, thus affording a considerable cost saving. Exchange, factory-repaired and tested assemblies are available only on a trade-in basis; therefore, the defective assemblies must be returned for credit. For this reason, assemblies required for spare parts stock must be ordered by the new assembly part number.

Table 6-1. Part Numbers for Restored Assemblies

Reference Designation	Description	Part Number[1]	
		Restored Assembly	New Assembly
A3	Central Processing Unit Assembly	00438-69003	00438-60003
A5	Main Amplifier Assembly	00438-69005	00438-60005

[1] When ordering extra assemblies for spare parts stock, use new assembly part number only. Restored orders require return of the defective part.

Table 6-2. Reference Designations and Abbreviations (1 of 2)

REFERENCE DESIGNATIONS

A . . . . . assembly
AT . . attenuator; isolator; termination
B . . . . . fan; motor
BT . . . . . battery
C . . . . . capacitor
CP . . . . . coupler
CR . . . . . diode; diode thyristor; varactor
DC . . . directional coupler
DL . . . . . delay line
DS . . . . . annunciator; signaling device (audible or visual); lamp; LED
E . . . . . miscellaneous electrical part
F . . . . . fuse
FL . . . . . filter
H . . . . . hardware
HY . . . . . circulator
J . . . electrical connector (stationary portion); jack
K . . . . . relay
L . . . . . coil; inductor
M . . . . . meter
MP . . . . . miscellaneous mechanical part
P . . . electrical connector (movable portion); plug
Q . . . . . transistor: SCR; triode thyristor
R . . . . . resistor
RT . . . . . thermistor
S . . . . . switch
T . . . . . transformer
TB . . . . . terminal board
TC . . . . . thermocouple
TP . . . . . test point
U . . . . . integrated circuit; microcircuit
V . . . . . electron tube
VR . . . . voltage regulator; breakdown diode
W . . . . cable; transmission path; wire
X . . . . . socket
Y . . . . crystal unit (piezoelectric or quartz)
Z . . . . tuned cavity; tuned circuit

ABBREVIATIONS

A . . . . . ampere
ac . . . . alternating current
ACCESS . . . . . accessory
ADJ . . . . . adjustment
A/D . . . . analog-to-digital
AF . . . . . audio frequency
AFC . . . . . automatic frequency control
AGC . . . . . automatic gain control
AL . . . . . aluminum
ALC . . . . . automatic level control
AM . . . amplitude modulation
AMPL . . . . . amplifier
APC . . . . automatic phase control
ASSY . . . . . assembly
AUX . . . . . auxiliary
avg . . . . . average
AWG . . . . American wire gauge
BAL . . . . . balance
BCD . . . . . binary coded decimal
BD . . . . . board
BE CU . . . . . beryllium copper
BFO . . . . . beat frequency oscillator
BH . . . . . binder head
BKDN . . . . . breakdown
BP . . . . . bandpass
BPF . . . . . bandpass filter
BRS . . . . . brass
BWO . . . . . backward-wave oscillator
CAL . . . . . calibrate
ccw . . counter-clockwise
CER . . . . . ceramic
CHAN . . . . . channel
cm . . . . . centimeter
CMO . . cabinet mount only
COAX . . . . . coaxial
COEF . . . . . coefficient
COM . . . . . common
COMP . . . . . composition
COMPL . . . . . complete
CONN . . . . . connector
CP . . . . . cadmium plate
CRT . . . cathode-ray tube
CTL . . . . complementary transistor logic
CW . . . . . continuous wave
cw . . . . . clockwise
cm . . . . . centimeter
D/A . . . . digital-to-analog
dB . . . . . decibel
dBm . . . . decibel referred to 1 mW
dc . . . . . direct current
deg . . degree (temperature interval or difference)
° . . . . . degree (plane angle)
°C . . . . . degree Celsius (centigrade)
°F . . . . degree Fahrenheit
°K . . . . . degree Kelvin
DEPC . . deposited carbon
DET . . . . . detector
diam . . . . . diameter
DIA . . . diameter (used in parts list)
DIFF AMPL . . differential amplifier
div . . . . . division
DPDT . . . . . double-pole, double-throw
DR . . . . . drive
DSB . . . . double sideband
DTL . . . . diode transistor logic
DVM . . . digital voltmeter
ECL . . . . emitter coupled logic
EMF . . electromotive force
EDP . . . . . electronic data processing
ELECT . . . . . electrolytic
ENCAP . . . . encapsulated
EXT . . . . . external
F . . . . . farad
FET . . . . . field-effect transistor
F/F . . . . . flip-flop
FH . . . . . flat head
FIL H . . . . . fillister head
FM . . frequency modulation
FP . . . . . front panel
FREQ . . . . . frequency
FXD . . . . . fixed
g . . . . . gram
GE . . . . . germanium
GHz . . . . . gigahertz
GL . . . . . glass
GRD . . . . . ground(ed)
H . . . . . henry
h . . . . . hour
HET . . . . . heterodyne
HEX . . . . . hexagonal
HD . . . . . head
HDW . . . . . hardware
HF . . . . . high frequency
HG . . . . . mercury
HI . . . . . high
HP . . . . . Hewlett-Packard
HPF . . . . . high pass filter
HR . . . . . hour (used in parts list)
HV . . . . . high voltage
Hz . . . . . Hertz
IC . . . . integrated circuit
ID . . . . . inside diameter
IF . . . . . intermediate frequency
IMPG . . . . . impregnated
in . . . . . inch
INCD . . . . . incandescent
INCL . . . . . include(s)
INP . . . . . input
INS . . . . . insulation
INT . . . . . internal
kg . . . . . kilogram
kHz . . . . . kilohertz
kΩ . . . . . kilohm
kV . . . . . kilovolt
lb . . . . . pound
LC . . . . . inductance-capacitance
LED . . light-emitting diode
LF . . . . . low frequency
LG . . . . . long
LH . . . . . left hand
LIM . . . . . limit
LIN . . . linear taper (used in parts list)
lin . . . . . linear
LK WASH . . . lock washer
LO . . . low; local oscillator
LOG . . . . logarithmic taper (used in parts list)
log . . . . . logrithm(ic)
LPF . . . . . low pass filter
LV . . . . . low voltage
m . . . . . meter (distance)
mA . . . . . milliampere
MAX . . . . . maximum
MΩ . . . . . megohm
MEG . . . . meg (10^6) (used in parts list)
MET FLM . . . . metal film
MET OX . . metallic oxide
MF . . . medium frequency; microfarad (used in parts list)
MFR . . . . . manufacturer
mg . . . . . milligram
MHz . . . . . megahertz
mH . . . . . millihenry
mho . . . . . mho
MIN . . . . . minimum
min . . . . . minute (time)
. . ' . . . . . minute (plane angle)
MINAT . . . . . miniature
mm . . . . . millimeter

NOTE

All abbreviations in the parts list will be in upper-case.

Table 6-2. Reference Designations and Abbreviations (2 of 2)

MOD . . . . . modulator
MOM . . . . . momentary
MOS . . . . . metal-oxide semiconductor
ms . . . . . millisecond
MTG . . . . . mounting
MTR . . . meter (indicating device)
mV . . . . . millivolt
mVac . . . . . millivolt, ac
mVdc . . . . . millivolt, dc
mVpk . . . . millivolt, peak
mVp-p . . . millivolt, peak-to-peak
mVrms . . . . millivolt, rms
mW . . . . . milliwatt
MUX . . . . . multiplex
MY . . . . . mylar
μA . . . . . microampere
μF . . . . . microfarad
μH . . . . . microhenry
μmho . . . . . micromho
μs . . . . . microsecond
μV . . . . . microvolt
μVac . . . . . microvolt, ac
μVdc . . . . . microvolt, dc
μVpk . . . microvolt, peak
μVp-p . . . microvolt, peak-to-peak
μVrms . . . . microvolt, rms
μW . . . . . microwatt
nA . . . . . nanoampere
NC . . . . . no connection
N/C . . . . normally closed
NE . . . . . neon
NEG . . . . . negative
nF . . . . . nanofarad
NI PL . . . . . nickel plate
N/O . . . . . normally open
NOM . . . . . nominal
NORM . . . . . normal
NPN . . . negative-positive-negative
NPO . . . . negative-positive zero (zero temperature coefficient)
NRFR . . not recommended for field replacement
NSR . . . . . not separately replaceable
ns . . . . . nanosecond
nW . . . . . nanowatt
OBD . . . order by description
OD . . . . . outside diameter
OH . . . . . oval head
OP AMPL . . . operational amplifier
OPT . . . . . option
OSC . . . . . oscillator
OX . . . . . oxide
oz . . . . . ounce
Ω . . . . . ohm
P . . . . peak (used in parts list)
PAM . . . . pulse-amplitude modulation
PC . . . . . printed circuit
PCM . . pulse-code modulation; pulse-count modulation
PDM . . . . . pulse-duration modulation
pF . . . . . picofarad
PH BRZ . phosphor bronze
PHL . . . . . Phillips
PIN . . . positive-intrinsic-negative
PIV . . . . . peak inverse voltage
pk . . . . . peak
PL . . . . . phase lock
PLO . . . . . phase lock oscillator
PM . . . . phase modulation
PNP . . . positive-negative-positive
P/O . . . . . part of
POLY . . . . . polystyrene
PORC . . . . . porcelain
POS . . positive; position(s) (used in parts list)
POSN . . . . . position
POT . . . . . potentiometer
p-p . . . . . peak-to-peak
PP . . . peak-to-peak (used in parts list)
PPM . . . . . pulse-position modulation
PREAMPL . . . preamplifier
PRF . . . . pulse-repetition frequency
PRR . . . . pulse repetition rate
ps . . . . . picosecond
PT . . . . . point
PTM . . . . . pulse-time modulation
PWM . . . . . pulse-width modulation
PWV . . . . . peak working voltage
RC . . . . . resistance-capacitance
RECT . . . . . rectifier
REF . . . . . reference
REG . . . . . regulated
REPL . . . . . replaceable
RF . . . . . radio frequency
RFI . . . . radio frequency interference
RH . . . . round head; right hand
RLC . . . . . resistance-inductance-capacitance
RMO . . . rack mount only
rms . . . . root-mean-square
RND . . . . . round
ROM . . read-only memory
R&P . . . . . rack and panel
RWV . . . reverse working voltage
S . . . scattering parameter
s . . . . . second (time)
. . . " . second (plane angle)
S-B . . . . . slow-blow (fuse) (used in parts list)
SCR . . . silicon controlled rectifier; screw
SE . . . . . selenium
SECT . . . . . sections
SEMICON . . . . . semiconductor
SHF . . . . . superhigh frequency
SI . . . . . silicon
SIL . . . . . silver
SL . . . . . slide
SNR . . signal-to-noise ratio
SPDT . . . . . single-pole, double-throw
SPG . . . . . spring
SR . . . . . split ring
SPST . . . . . single-pole, single-throw
SSB . . . . . single sideband
SST . . . . . stainless steel
STL . . . . . steel
SQ . . . . . square
SWR . . standing-wave ratio
SYNC . . . . . synchronize
T . . timed (slow-blow fuse)
TA . . . . . tantalum
TC . . . . . temperature compensating
TD . . . . . time delay
TERM . . . . . terminal
TFT . . thin-film transistor
TGL . . . . . toggle
THD . . . . . thread
THRU . . . . . through
TI . . . . . titanium
TOL . . . . . tolerance
TRIM . . . . . trimmer
TSTR . . . . . transistor
TTL . . . transistor-transistor logic
TV . . . . . television
TVI television interference
TWT . . traveling wave tube
U . . . . . micro (10^{-6}) (used in parts list)
UF . . . microfarad (used in parts list)
UHF . . ultrahigh frequency
UNREG . . . . unregulated
V . . . . . volt
VA . . . . . voltampere
Vac . . . . . volts, ac
VAR . . . . . variable
VCO . . . voltage-controlled oscillator
Vdc . . . . . volts, dc
VDCW . . volts, dc, working (used in parts list)
V(F) . . . . . volts, filtered
VFO . . variable-frequency oscillator
VHF . . . . . very-high frequency
Vpk . . . . . volts, peak
Vp-p . . volts, peak-to-peak
Vrms . . . . . volts, rms
VSWR . . . voltage standing wave ratio
VTO . . . . . voltage-tuned oscillator
VTVM . . . . vacuum-tube voltmeter
V(X) . . . . . volts, switched
W . . . . . watt
W/ . . . . . with
WIV . . . . working inverse voltage
WW . . . . . wirewound
W/O . . . . . without
YIG . . yttrium-iron-garnet
Z_o . . . . . characteristic impedance

NOTE

All abbreviations in the parts list will be in upper-case.

MULTIPLIERS

Abbreviation	Prefix	Multiple
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	atto	10^{-18}

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1	00438-60001	1	1	KEYBOARD ASSEMBLY	28480	00438-60001
A1J1	1200-0607	0	2	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607
A1MP1	5041-2839	0	1	KEY CAP A	28480	5041-2839
A1MP2	5041-2840	3	1	KEY CAP B	28480	5041-2840
A1MP3	5041-2842	5	1	KEY CAP B/A	28480	5041-2842
A1MP4	5041-0309	5	2	KEY CAP 1/4 (BLANK)	28480	5041-0309
A1MP5	5041-2841	4	1	KEY CAP ZERO	28480	5041-2841
A1MP6	5041-2850	5	1	KEY CAP CAL ADJ	28480	5041-2850
A1MP7	5041-2851	6	1	KEY CAP CAL FACTOR	28480	5041-2851
A1MP8	5041-2854	9	1	KEY CAP OFFSET	28480	5041-2854
A1MP9	5041-2844	7	1	KEY CAP STORE	28480	5041-2844
A1MP10	5041-2849	2	1	KEY CAP REL	28480	5041-2849
A1MP11	5041-2848	1	1	KEY CAP DBM WATT	28480	5041-2848
A1MP12	5041-2886	7	1	KEY CAP LCL	28480	5041-2886
A1MP13	5041-2838	9	1	KEY CAP SHIFT	28480	5041-2838
A1MP14	5041-0309	5		KEY CAP 1/4 (BLANK)	28480	5041-0309
A1MP15	5041-2846	9	1	KEY CAP AUTO RANGE	28480	5041-2846
A1MP16	5041-2852	7	1	KEY CAP MNL RANGE	28480	5041-2852
A1MP17	5041-2847	0	1	KEY CAP AUTO FILTER	28480	5041-2847
A1MP18	5041-2853	8	1	KEY CAP MNL FILTER	28480	5041-2853
A1MP19	5041-2845	8	1	KEY CAP RECALL	28480	5041-2845
A1MP20	5041-2855	0	1	KEY CAP PRE SET	28480	5041-2855
A1MP21	5041-2843	6	1	KEY CAP OSC	28480	5041-2843
A1S1- A1S21	5060-9436	7	3 21	PUSHBUTTON SWITCH P.C. SWITCH	28480	5060-9436
A2	00438-60002	2	1	DISPLAY ASSEMBLY	28480	00438-60002
A2DS1	1990-0693	7	8	DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS2	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS3	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS4	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS5	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS6	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS7	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS8	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS9	1990-0759	6	5	LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS10	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS11	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS12	1990-0587	8	2	DISPLAY-NUM-SEG 5-CHAR .11-H	28480	5082-7415
A2DS13	1990-0587	8		DISPLAY-NUM-SEG 5-CHAR .11-H	28480	5082-7415
A2DS14	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS15	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS16	1990-0665	3	1	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665
A2J1	1251-5720	5	1	CONNECTOR 34-PIN M POST TYPE	28480	1251-5720
A2MP1	0380-0059	5	1	SPACER-RVT-ON .25-IN-LG .152-IN-ID	00000	ORDER BY DESCRIPTION
A2MP2	00438-80006	8	1	LABEL-INFO	28480	00438-80006
A2XA1	1200-1055	4	10	SOCKET-IC 14 PIN	28480	1200-1055
A2XA2	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA3	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA4	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA5	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA6	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA7	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA8	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA9	1200-1056	5	5	SOCKET-IC 16 PIN	28480	1200-1056
A2XA10	1200-1056	5		SOCKET-IC 16 PIN	28480	1200-1056

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A2XA11	1200-1056	5		SOCKET-IC 16 PIN	28480	1200-1056
A2XA12	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA13	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA14	1200-1056	5		SOCKET-IC 16 PIN	28480	1200-1056
A2XA15	1200-1056	5		SOCKET-IC 16 PIN	28480	1200-1056
A3	00438-60003	3	1	CENTRAL PROCESSING UNIT ASSEMBLY	28480	00438-60003
A3BT1	1420-0314	2	1	BATTERY 3V 0.14A-HR LITHIUM POLYCARBON	28480	1420-0314
A3C1	0180-2815	1	1	CAPACITOR-FXD 100UF+-20% 10VDC TA	28480	0180-2815
A3C2	0180-2620	6	2	CAPACITOR-FXD 2.2UF+-10% 50VDC TA	25088	D2R2GS1B50K
A3C3	0160-4554	7	49	CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C4	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C5	0180-1745	4	1	CAPACITOR-FXD 1.5UF+-10% 20VDC TA	56289	150D155X9020A2
A3C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C7	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C8	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C9	0160-0574	3	1	CAPACITOR-FXD .022UF +-20% 100VDC CER	28480	0160-0574
A3C10	0180-2617	1	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	25088	D6R8GS1B35K
A3C11	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C12	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C13	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C14	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C15	0160-3455	5	1	CAPACITOR-FXD 470PF +-10% 1KVDC CER	28480	0160-3455
A3C16	0180-0374	3	3	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A3C17	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C18	0180-2620	6		CAPACITOR-FXD 2.2UF+-10% 50VDC TA	25088	D2R2GS1B50K
A3C19	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C20	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C21	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C22	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C23	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C24				NOT ASSIGNED		
A3C25	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C26	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C27	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C28	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C29	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C30	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C31	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C32	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C33	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C34	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C35	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C36	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C37	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C38	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C39	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C40	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C41	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C42	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C43	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C44	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3CR1	1901-0376	6	1	DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A3CR2	1901-1085	6	1	DIODE-SM SIG SCHOTTKY	28480	1901-1085
A3CR3	1901-0539	3	1	DIODE-SM SIG SCHOTTKY	28480	1901-0539
A3CR4				NOT ASSIGNED		
A3CR5				NOT ASSIGNED		
A3CR6	1906-0275	4	3	DIODE ARRAY	28480	1906-0275
A3CR7	1906-0275	4		DIODE ARRAY	28480	1906-0275
A3CR8	1906-0275	4		DIODE ARRAY	28480	1906-0275

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3DS1	1990-0933	8	2	LED-LAMP RED	28480	1990-0933
A3DS2	1990-0933	8		LED-LAMP RED	28480	1990-0933
A3J1	1251-5615	7	1	CONNECTOR 34-PIN M POST TYPE	28480	1251-5615
A3J2	1251-8934	9	1	CONNECTOR 3-PIN M POST TYPE	28480	1251-8934
A3J3	1251-4634	8	2	CONNECTOR 20-PIN M POST TYPE	28480	1251-4634
A3J4	1200-0607	0		SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607
A3J5	1251-4833	9	2	CONNECTOR 34-PIN M POST TYPE	28480	1251-4833
A3J6	1251-4700	9	2	CONNECTOR 3-PIN M POST TYPE	28480	1251-4700
A3MP1	1400-1210	7	1	HOLDER-BAT 1-WD	28480	1400-1210
A3MP2	1200-0638	7	1	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A3MP3	1200-0654	7	1	SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A3MP4	0340-0944	3	1	INSULATOR-IC NYLON BLACK	28480	0340-0944
A3MP5	1200-0567	1	2	SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567
A3MP6	00438-20029	9	5	HINGE RIVETED	28480	00438-20029
A3MP7	0403-0179	0	3	BUMPER FOOT-ADH MTG	28480	0403-0179
A3MP8	3050-0300	3	1	WASHER-FL NM NO. 4 .125-IN-ID .25-IN-OD	28480	3050-0300
A3MP9	3050-0892	8	1	WASHER-FL MTLC 3.5 MM 3.8-MM-ID	28480	3050-0892
A3MP10	0515-0506	4	1	SCREW-MACHINE ASSEMPLY M3.5 X 0.6 6MM-LG	00000	ORDER BY DESCRIPTION
A3MP11	0361-0009	5	4	RIVET-SEMITUB OVH .123 DIA .188LG	00000	ORDER BY DESCRIPTION
A3MP12	00438-60034	0	2	CABLE ASSEMBLY MICRO	28480	00438-60034
A3Q1- A3Q19	1853-0281	9	19	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A3Q20	1854-0477	7	1	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A3R1	1810-0280	8	5	NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A3R2	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A3R3	0698-7283	4	1	RESISTOR 90.9K 1% .05W F TC=0+-100	24546	C3-1/8-T0-9092-F
A3R4	0698-7268	5	5	RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R5	0698-7268	5		RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R6	0698-7212	9	4	RESISTOR 100 1% .05W F TC=0+-100	24546	C3-1/8-T0-100R-F
A3R7	0698-7212	9		RESISTOR 100 1% .05W F TC=0+-100	24546	C3-1/8-T0-100R-F
A3R8	0698-7236	7	3	RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A3R9	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A3R10	0698-7268	5		RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R11	0698-7268	5		RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R12	0698-7268	5		RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R13	0698-7269	6	1	RESISTOR 23.7K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2372-F
A3R14	0698-3460	1	1	RESISTOR 422K 1% .125W F TC=0+-100	28480	0698-3460
A3R15	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A3R16	0698-7212	9		RESISTOR 100 1% .05W F TC=0+-100	24546	C3-1/8-T0-100R-F
A3R17	0698-7220	9	7	RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R18	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R19	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R20	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R21	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R22	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R23	0698-7253	8	1	RESISTOR 5.11K 1% .05W F TC=0+-100	24546	C3-1/8-T0-5111-F
A3R24	0757-0317	7	2	RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F
A3R25	0698-7260	7	2	RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R26	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R27	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A3R28	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R29	0698-7212	9		RESISTOR 100 1% .05W F TC=0+-100	24546	C3-1/8-T0-100R-F
A3R30	1810-0273	9	2	NETWORK-RES 10-SIP470.0 OHM X 9	01121	210A471
A3R31	1810-0265	9	2	NETWORK-RES 16-DIP680.0 OHM X 8	01121	316B681
A3R32	1810-0265	9		NETWORK-RES 16-DIP680.0 OHM X 8	01121	316B681
A3R33	1810-0247	7	3	NETWORK-RES 16-DIP220.0 OHM X 8	01121	316B221
A3R34	0698-7232	3	1	RESISTOR 681 1% .05W F TC=0+-100	24546	C3-1/8-T0-681R-F
A3R35	1810-0247	7		NETWORK-RES 16-DIP220.0 OHM X 8	01121	316B221
A3R36	1810-0247	7		NETWORK-RES 16-DIP220.0 OHM X 8	01121	316B221
A3R37	0698-3430	5	9	RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R38	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R39	1810-0411	7	1	NETWORK-RES 10-SIP50.0 OHM X 9	56289	256CK500X2PD
A3R40	0757-0984	4	2	RESISTOR 10 1% .5W F TC=0+-100	28480	0757-0984

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
A3R41	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R42	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R43	0757-0984	4		RESISTOR 10 1% .5W F TC=0+-100	28480	0757-0984
A3R44	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R45	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R46	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R47	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R48	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R49	1810-0273	9		NETWORK-RES 10-SIP470.0 OHM X 9	01121	210A471
A3S1	3101-2172	0	1	SWITCH-TGL DIP-RKR-ASSY SPDT .05A 30VDC	28480	3101-2172
A3TP1	0360-0535	0	51	TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP2	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP3	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP4	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP5	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP6	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP7	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP8	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP9	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP10	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP11	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP12	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3U1	1820-2075	4	3	IC MISC TTL LS	01295	SN74LS245N
A3U2	1820-2024	3	7	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U3	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U4	1820-1858	9	4	IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A3U5	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A3U6	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A3U7	1820-1281	2	2	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N
A3U8	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N
A3U9	00438-80002	4	1	PROM PROGRAMMED	28480	00438-80002
A3U10	00438-80003	5	1	PROM PROGRAMMED	28480	00438-80003
A3U11	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U12	1818-1768	5	2	IC CMOS 16384 (16K) STAT RAM 150-NS 3-S	S0545	UPD446C-1(PER HP DWG)
A3U13	1818-1768	5		IC CMOS 16384 (16K) STAT RAM 150-NS 3-S	S0545	UPD446C-1(PER HP DWG)
A3U14	1820-1212	9	2	IC FF TTL LS J-K NEG-EDGE-TRIG	01295	SN74LS112AN
A3U15	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U16	1820-2483	8	1	IC RCVR TTL LS BUS OCTL	01295	SN75161N
A3U17	1820-2485	0	1	IC RCVR TTL LS BUS OCTL	01295	SN75160N
A3U18	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U19	1820-2624	9	1	IC-MPU; CLK FREQ=2MHZ, ENHANCED 6800	28480	1820-2624
A3U20	1820-2705	7	1	IC-8-BIT/16-BIT SYSTEM TIMING CONTROLLER	28480	1820-2705
A3U21	1820-2983	3	2	IC-PERIPHERAL INTERFACE ADAPTER;CLK=2MHZ	28480	1820-2983
A3U22	1820-2983	3		IC-PERIPHERAL INTERFACE ADAPTER;CLK=2MHZ	28480	1820-2983
A3U23	1820-1427	8	1	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS156N
A3U24	1820-0668	7	5	IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U25	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U26	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U27	1820-1216	3	2	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A3U28	00438-80001	3	2	PAL PROGRAMMED	28480	00438-80001
A3U29	1820-2549	7	1	IC-8291A P HPIB	28480	1820-2549
A3U30	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U31	1820-1729	3	2	IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A3U32	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A3U33	1820-1281	2		IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N
A3U34	1820-1753	3	1	IC FF CMOS D-TYPE POS-EDGE-TRIG	27014	MM74C74N
A3U35	1826-0175	3	1	IC COMPARATOR GP DUAL 14-DIP-P PKG	27014	LM319N
A3U36	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A3U37	1820-1199	1	2	IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A3U38	1820-1212	9		IC FF TTL LS J-K NEG-EDGE-TRIG	01295	SN74LS112AN
A3U39	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N
A3U40	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
A3U41	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U42	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U43	1820-1851	2	1	IC ENCDR TTL LS	01295	SN74LS148N
A3U44	1820-2130	2	3	IC SWITCH CUR QUAD 16-DIP-P PKG	13606	ULN-2074B
A3U45	1820-2130	2		IC SWITCH CUR QUAD 16-DIP-P PKG	13606	ULN-2074B
A3U46	1820-2130	2		IC SWITCH CUR QUAD 16-DIP-P PKG	13606	ULN-2074B
A3Y1	1813-0130	3	1	IC OSC HYBRID	34344	K1148A-16.0MHZ
A4	00438-60004	4	1	INPUT AMPLIFIER ASSEMBLY	28480	00438-60004
A4C1	0180-2139	2	4	CAPACITOR-FXD 10UF+-20% 60VDC TA	06001	69F177G7
A4C2	0180-2139	2		CAPACITOR-FXD 10UF+-20% 60VDC TA	06001	69F177G7
A4C3	0160-3336	1	5	CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A4C4	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A4C5	0160-3336	1		CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A4C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A4C7	0180-2139	2		CAPACITOR-FXD 10UF+-20% 60VDC TA	06001	69F177G7
A4C8	0180-2139	2		CAPACITOR-FXD 10UF+-20% 60VDC TA	06001	69F177G7
A4C9	0180-2206	4	4	CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C10	0180-2206	4		CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C11	0160-0160	3	3	CAPACITOR-FXD 8200PF +-10% 200VDC POLYE	28480	0160-0160
A4C12	0160-0160	3		CAPACITOR-FXD 8200PF +-10% 200VDC POLYE	28480	0160-0160
A4C13	0180-0229	7	3	CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A4C14	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A4C15	0180-2206	4		CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C16	0180-2206	4		CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C17	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A4C18	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A4C19	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A4C20	0160-3439	5	3	CAPACITOR-FXD .039UF +-5% 200VDC	28480	0160-3439
A4C21	0160-3439	5		CAPACITOR-FXD .039UF +-5% 200VDC	28480	0160-3439
A4C22	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A4CR1	1901-0895	4	4	DIODE-SM SIG SCHOTTKY	28480	1901-0895
A4CR2	1901-0895	4		DIODE-SM SIG SCHOTTKY	28480	1901-0895
A4CR3	1901-0895	4		DIODE-SM SIG SCHOTTKY	28480	1901-0895
A4CR4	1901-0895	4		DIODE-SM SIG SCHOTTKY	28480	1901-0895
A4J1	1251-5547	4	4	CONNECTOR 6-PIN M POST TYPE	28480	1251-5547
A4J2	1251-5286	8	1	CONNECTOR 4-PIN M POST TYPE	28480	1251-5286
A4J3	1251-8043	1	4	CONN-POST TYPE .100-PIN-SPCG 5-CONT	28480	1251-8043
A4J4	1251-8043	1		CONN-POST TYPE .100-PIN-SPCG 5-CONT	28480	1251-8043
A4J5	1251-5547	4		CONNECTOR 6-PIN M POST TYPE	28480	1251-5547
A4J6	1250-1255	1	1	CONNECTOR-RF SMB M PC 50-OHM	28480	1250-1255
A4J7	1251-5547	4		CONNECTOR 6-PIN M POST TYPE	28480	1251-5547
A4J8	1251-8043	1		CONN-POST TYPE .100-PIN-SPCG 5-CONT	28480	1251-8043
A4J9	1251-8043	1		CONN-POST TYPE .100-PIN-SPCG 5-CONT	28480	1251-8043
A4J10	1251-7100	9	2	CONNECTOR 26-PIN M POST TYPE	28480	1251-7100
A4J11	1251-5547	4		CONNECTOR 6-PIN M POST TYPE	28480	1251-5547
A4J12	1251-0600	0	6	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4J13	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4J14	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4J15	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4L1	9100-3922	4	2	INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A4L2	9100-3922	4		INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A4L3	9100-2247	4	1	INDUCTOR RF-CH-MLD 100NH 10% .105DX.26LG	28480	9100-2247
A4Q1	1854-0810	2	5	TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A4Q2	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A4Q3	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A4Q4	1853-0459	3	6	TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A4Q5	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459

See introduction to this section for ordering information
***Indicates factory selected value**

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4R1	0811-1557	5	1	RESISTOR 15 5% 3W PW TC=0+-20	28480	0811-1557
A4R2	0757-0346	2	4	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A4R3	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A4R4	0698-3447	4	4	RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A4R5	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A4R6	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A4R7	0698-3447	4		RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A4R8	0698-3450	9	5	RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A4R9	0698-3450	9		RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A4R10	0757-0465	6	12	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R11	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R12	0698-3156	2	8	RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A4R13	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A4R14	0757-0459	8	2	RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
A4R15	0757-0459	8		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
A4R16	0698-3159	5	2	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
A4R17	0698-3159	5		RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
A4R18	0698-3450	9		RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A4R19	0698-3450	9		RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A4R20	0757-0444	1	3	RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A4R21	0757-0442	9	11	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R22	0757-0444	1		RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A4R23	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R24	0757-0463	4	3	RESISTOR 82.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8252-F
A4R25	0757-0463	4		RESISTOR 82.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8252-F
A4R26	2100-2655	1	4	RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN	73138	82PR100K
A4R27	2100-2655	1		RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN	73138	82PR100K
A4R28	0698-3451	0	2	RESISTOR 133K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1333-F
A4R29	0698-3451	0		RESISTOR 133K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1333-F
A4R30	0698-3160	8	3	RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A4R31	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A4R32	0698-0083	8	2	RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A4R33	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A4R34	2100-2655	1		RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN	73138	82PR100K
A4R35	2100-2655	1		RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN	73138	82PR100K
A4R36	0698-0084	9	2	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F
A4R37	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F
A4R38	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R39	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R40	0698-3154	0	3	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A4R41	0757-0200	7	2	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A4R42	0757-0460	1	2	RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A4R43	2100-2030	6	1	RESISTOR-TRMR 20K 10% C TOP-ADJ 1-TRN	73138	82PR20K
A4R44	0757-0460	1		RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A4R45	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A4R46	0757-0200	7		RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A4R47	0757-0279	0	3	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R48	0757-0280	3	11	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R49	0757-0422	5	1	RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A4R50	0698-3446	3	1	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F
A4R51	0698-0085	0	2	RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A4R52	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A4R53	0698-3441	8	7	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A4R54	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A4R55	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A4R56	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A4TP1	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP2	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP3	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP4	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP5	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP6	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP7	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP8	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP9	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP10	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4U1	1826-0547	3	2	IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-P	01295	TL072ACP
A4U2	1826-1019	6	6	ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A4U3	1826-0547	3		IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-P	01295	TL072ACP
A4U4	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A4U5	1826-0600	9	3	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL074ACN
A4VR1	1902-3002	3	4	DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	28480	1902-3002
A4VR2	1902-3002	3		DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	28480	1902-3002
A4VR3	1902-3002	3		DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	28480	1902-3002
A4VR4	1902-3002	3		DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	28480	1902-3002
A4W1	8159-0005	0	11	RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W2	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W3	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W4	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W5	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W6	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W7				NOT ASSIGNED		
A4W8				NOT ASSIGNED		
A4W9	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W10	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W11	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W12	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A5	00438-60005	5	1	MAIN AMPLIFIER ASSEMBLY	28480	00438-60005
A5C1	0180-0291	3	7	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C2	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C3	0180-0197	8	5	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C4	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A5C5	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A5C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A5C7				NOT ASSIGNED		
A5C8	0160-0127	2	2	CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A5C9	0160-2290	4	1	CAPACITOR-FXD .15UF +-10% 80VDC POLYE	28480	0160-2290
A5C10	0160-3336	1		CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A5C11	0160-3336	1		CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A5C12	0160-3336	1		CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A5C13	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C14	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C15	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C16	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C17	0160-2199	2	3	CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
A5C18	0160-2199	2		CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
A5C19	0160-3762	7	1	CAPACITOR-FXD .68UF +-5% 50VDC MET-POLYC	28480	0160-3762
A5C20	0160-3702	5	1	CAPACITOR-FXD .027UF +-5% 50VDC	28480	0160-3702
A5C21	0160-3402	2	2	CAPACITOR-FXD 1UF +-5% 50VDC MET-POLYC	28480	0160-3402
A5C22	0160-3661	5	2	CAPACITOR-FXD .1UF +-5% 50VDC MET-P[illegible]C	28480	0160-3661
A5C23	0180-0373	2	2	CAPACITOR-FXD .68UF+-10% 35VDC TA	56289	150D684X9035A2
A5C24	0180-0373	2		CAPACITOR-FXD .68UF+-10% 35VDC TA	56289	150D684X9035A2
A5C25	0160-4557	0	1	CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A5C26	0160-3402	2		CAPACITOR-FXD 1UF +-5% 50VDC MET-POLYC	28480	0160-3402
A5C27	0160-3439	5		CAPACITOR-FXD .039UF +-5% 200VDC	28480	0160-3439
A5C28	0160-3661	5		CAPACITOR-FXD .1UF +-5% 50VDC MET-POLYC	28480	0160-3661
A5C29	0160-0160	3		CAPACITOR-FXD 8200PF +-10% 200VDC POLYE	28480	0160-0160
A5C30	0160-4325	0	1	CAPACITOR-FXD .33UF +-5% 50VDC MET-POLYC	28480	0160-4325
A5C31	0160-0161	4	3	CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A5C32	0160-0168	1	1	CAPACITOR-FXD .1UF +-10% 200VDC POLYE	28480	0160-0168
A5C33	0160-0155	6	1	CAPACITOR-FXD 3300PF +-10% 200VDC POLYE	28480	0160-0155
A5C34	0160-2291	5	1	CAPACITOR-FXD .18UF +-10% 80VDC POLYE	28480	0160-2291
A5C35	0160-4638	8	1	CAPACITOR-FXD .1UF +-2% 100VDC	28480	0160-4638
A5C36	0160-2199	2		CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
A5CR1	1901-0050	3	3	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A5J1	1251-4700	9		CONNECTOR 3-PIN M POST TYPE	28480	1251-4700
A5J2	1251-4634	8		CONNECTOR 20-PIN M POST TYPE	28480	1251-4634
A5J3	1251-7100	9		CONNECTOR 26-PIN M POST TYPE	28480	1251-7100
A5J4	1250-1377	8	1	CONNECTOR-RF SMB M PC 50-OHM	28480	1250-1377
A5L1	9140-0210	1	1	INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A5MP1	0361-0009	5		RIVET-SEMITUB OVH .123 DIA .188LG	00000	ORDER BY DESCRIPTION
A5MP2	00438-20029	9		HINGE RIVETED	28480	00438-20029
A5Q1	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q2	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q3	1855-0420	2	1	TRANSISTOR J-FET 2N4391 N-CHAN D-MODE	01295	2N4391
A5Q4	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q5	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A5Q6	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q7	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A5Q8	1855-0414	4	1	TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q9	1853-0314	9	1	TRANSISTOR PNP 2N2905A SI TO-39 PD=600MW	04713	2N2905A
A5R1	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A5R2	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A5R3	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A5R4	0699-0842	9	2	RESISTOR 6.19K .1% .125W F TC=0+-25	28480	0699-0842
A5R5	0698-3444	1	2	RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F
A5R6	0757-0274	5	2	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A5R7	0757-0439	4	1	RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A5R8	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A5R9	0757-0123	3	2	RESISTOR 34.8K 1% .125W F TC=0+-100	28480	0757-0123
A5R10	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A5R11	0698-8638	5	2	RESISTOR 3.16K .1% .125W F TC=0+-25	28480	0698-8638
A5R12	0698-8638	5		RESISTOR 3.16K .1% .125W F TC=0+-25	28480	0698-8638
A5R13	0699-0842	9		RESISTOR 6.19K .1% .125W F TC=0+-25	28480	0699-0842
A5R14	0757-0420	3	1	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A5R15	0699-0148	8	3	RESISTOR 31.6K .1% .1W F TC=0+-15	28480	0699-0148
A5R16	0757-0290	5	1	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A5R17	0699-0924	8	1	RESISTOR 11K .1% .125W F TC=0+-25	28480	0699-0924
A5R18	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R19	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R20	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R21	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R22	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R23	0811-3351	1	1	RESISTOR 11K .025% .05W PWW TC=0+-10	28480	0811-3351
A5R24	0811-3348	6	2	RESISTOR 111.11 .025% .05W PWW TC=0+-10	28480	0811-3348
A5R25	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R26	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R27	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R28	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R29	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R30	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R31	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R32	0698-3158	4	4	RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
A5R33	0698-3158	4		RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
A5R34	0698-3158	4		RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
A5R35	0698-3158	4		RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
A5R36	0698-3442	9	1	RESISTOR 237 1% .125W F TC=0+-100	24546	C4-1/8-T0-237R-F
A5R37	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A5R38	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R39	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A5R40	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A5R41	0757-0461	2	1	RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
A5R42	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R43	0757-0463	4		RESISTOR 82.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8252-F
A5R44	0698-3453	2	1	RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F
A5R45	0757-0470	3	1	RESISTOR 162K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1623-F

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
A5R46	0757-0288	1	2	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A5R47	0698-3157	3	1	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A5R48	0698-3161	9	1	RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F
A5R49	0757-0462	3	1	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
A5R50	0757-0444	1		RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A5R51	0698-3162	0	1	RESISTOR 46.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F
A5R52	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R53	0811-3350	0	1	RESISTOR 10K .025% .05W PWW TC=0+-10	28480	0811-3350
A5R54	0811-3349	7	1	RESISTOR 1K .025% .05W PWW TC=0+-10	28480	0811-3349
A5R55	0811-3348	6		RESISTOR 111.11 .025% .05W PWW TC=0+-10	28480	0811-3348
A5R56	0698-3455	4	1	RESISTOR 261K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2613-F
A5R57	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A5R58	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R59	0698-6360	6	1	RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A5R60	0757-0199	3	1	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A5R61	2100-3109	2	1	RESISTOR-TRMR 2K 10% C SIDE-ADJ 17-TRN	02111	43P202
A5R62	0757-0440	7	4	RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A5R63	0757-0123	3		RESISTOR 34.8K 1% .125W F TC=0+-100	28480	0757-0123
A5R64	0699-0148	8		RESISTOR 31.6K .1% .1W F TC=0+-15	28480	0699-0148
A5R65	0699-1172	0	1	RESISTOR:FXD 200K 0.1% -+50 PPM/OC	28480	0699-1172
A5R66	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A5R67	0698-3136	8	1	RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F
A5R68	0698-3450	9		RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A5R69	0757-0278	9	1	RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A5R70	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R71	0699-0148	8		RESISTOR 31.6K .1% .1W F TC=0+-15	28480	0699-0148
A5R72	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R73	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R74	0698-3449	6	1	RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F
A5R75	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R76	0757-0441	8	1	RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A5R77	0698-3150	6	1	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A5R78				NOT ASSIGNED		
A5R79	0757-0419	0	1	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A5R80	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R81	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R82	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R83	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R84	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5TP1-A5TP20	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A5U1	1826-0059	2	3	IC OP AMP GP TO-99 PKG	01295	LM201AL
A5U2	1826-0471	2	3	IC OP AMP LOW-DRIFT TO-99 PKG	28480	1826-0471
A5U3	1826-0861	4	1	IC CONV 10-B-D/A 16-DIP-P PKG	24355	AD7533LN
A5U4	1820-1997	7	5	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U5	1820-1934	2	2	IC CONV 8-B-D/A 16-DIP-C PKG	06665	DAC-08EQ
A5U6	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U7	1826-0098	9	1	IC COMPARATOR PRCN TO-99 PKG	27014	LM211H
A5U8	1826-0026	3	1	IC COMPARATOR PRCN TO-99 PKG	01295	LM311L
A5U9	1826-0471	2		IC OP AMP LOW-DRIFT TO-99 PKG	28480	1826-0471
A5U10	1820-1934	2		IC CONV 8-B-D/A 16-DIP-C PKG	06665	DAC-08EQ
A5U11	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U12	1826-0544	0	1	V REF 8-DIP-C	04713	MC1403U
A5U13	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A5U14	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U15	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A5U16	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U17	1826-0574	6	1	IC OP AMP LOW-DRIFT TO-99 PKG	07263	UA714LHC
A5U18	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A5U19	1826-1021	0	1	ANALOG MULTIPLEXER CHNL 16 -DIP-P	28480	1826-1021
A5U20	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A5U21	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A5U22	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A5U23	1826-0600	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL074ACN
A5U24	1826-0600	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL074ACN
A5U25	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5U26	1826-0059	2		IC OP AMP GP TO-99 PKG	01295	LM201AL
A5U27	1826-0059	2		IC OP AMP GP TO-99 PKG	01295	LM201AL
A5U28	1826-0471	2		IC OP AMP LOW-DRIFT TO-99 PKG	28480	1826-0471
A5VR1	1902-0680	7	3	DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	24046	1N827
A5VR2	1902-0947	9	1	DIODE-ZNR 3.6V 5% DO-35 PD=.4W TC=-.036%	28480	1902-0947
A5VR3	1902-0680	7		DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	24046	1N827
	3050-0079	3	2	WASHER-FL MM NO. 2 .094-IN-ID .188-IN-OD	28480	3050-0079
A6				NOT ASSIGNED		
A7				NOT ASSIGNED		
A8	00438-60008	8	1	RECTIFIER ASSEMBLY	28480	00438-60008
A8C1	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A8C2	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A8C3	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A8CR1	1906-0231	2	1	DIODE-CT-RECT 200V 15A	28480	1906-0231
A8CR2	1901-0028	5	10	DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A8CR3	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A8MP1	0515-0064	9	6	SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP2	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP3	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP4	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP5	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP6	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP7	0590-1076	3	6	THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP8	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP9	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP10	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP11	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP12	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP13	1200-0081	4	6	INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP14	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP15	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP16	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP17	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP18	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP19	1251-2313	6	6	CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP20	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP21	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP22	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP23	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP24	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP25	2190-0003	8	13	WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP26	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP27	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP28	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP29	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP30	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP31	00438-20021	1	1	HEATSINK RECT.	28480	00438-20021

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A8R1	0698-3438	3	1	RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F
A8U1	1826-0423	4	1	IC V RGLTR TO-3	27014	LM317K
A8U2	1826-0677	0	1	IC-LM338	28480	1826-0677
	6040-0239	9	3	LUBRICANT-GREASE SIL	05820	120
A9	00438-60009	9	1	REGULATOR ASSEMBLY	28480	00438-60009
A9C1	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A9C2	0160-0163	6	1	CAPACITOR-FXD .033UF +-10% 200VDC POLYE	28480	0160-0163
A9C3	0160-0161	4		CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A9C4	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A9C5	0160-0161	4		CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A9C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A9C7	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A9C8	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A9C9	0160-3638	6	2	CAPACITOR-FXD .22UF +80-20% 200VDC CER	28480	0160-3638
A9C10	0160-4535	4	1	CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535
A9C11	0180-0491	5	1	CAPACITOR-FXD 10UF+-20% 25VDC TA	28480	0180-0491
A9C12	0180-1743	2	2	CAPACITOR-FXD .1UF+-10% 35VDC TA	56289	150D104X9035A2
A9C13	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A9CR1	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR2	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR3	1901-0418	7	3	DIODE-PWR RECT 400V 1.5A	28480	1901-0418
A9CR4	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR5	1901-0418	7		DIODE-PWR RECT 400V 1.5A	28480	1901-0418
A9CR6	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR7	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR8	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A9CR9	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A9CR10	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR11	1901-0418	7		DIODE-PWR RECT 400V 1.5A	28480	1901-0418
A9DS1	1990-0486	6	4	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A9DS2	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A9DS3	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A9DS4	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A9MP1	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP2	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP3	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP4	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP5	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP6	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP7	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP8	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP9	0515-0054	7	5	SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A9MP10	0515-0054	7		SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A9MP11	0535-0004	9	9	NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A9MP12	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A9MP13	1205-0011	0	1	HEAT SINK TO-5/TO-39-CS	28480	1205-0011
A9MP14	1205-0353	3	3	HEAT SINK SGL PLSTC-PWR-CS	13103	6073B
A9MP15	1205-0353	3		HEAT SINK SGL PLSTC-PWR-CS	13103	6073B
A9MP16	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A9MP17	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A9MP18	3050-0105	6	7	WASHER-FL MTLC NO. 4 .125-IN-ID	28480	3050-0105
A9MP19	3050-0105	6		WASHER-FL MTLC NO. 4 .125-IN-ID	28480	3050-0105
A9MP20	5000-9043	6	1	PIN:P.C. BOARD EXTRACTOR	28480	5000-9043
A9MP21	5040-6843	2	1	EXTRACTOR, P.C. BOARD	28480	5040-6843
A9MP22	08673-20063	2	2	BUSHING	28480	08673-20063

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A9Q1	1884-0244	9	2	THYRISTOR-SCR VRRM=400	3L585	S2600D
A9Q2	1884-0244	9		THYRISTOR-SCR VRRM=400	3L585	S2600D
A9R1	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A9R2	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A9R3	2100-2633	5	2	RESISTOR-TRMR 1K 10% C SIDE-ADJ 1-TRN	30983	ET50X102
A9R4	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A9R5	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A9R6	0757-0418	9	1	RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A9R7	0757-0397	3	1	RESISTOR 68.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-68R1-F
A9R8	0757-0288	1		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A9R9	0698-3447	4		RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A9R10	0698-3447	4		RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A9R11	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A9R12	0698-3444	1		RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F
A9R13	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A9R14	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A9R15	0757-0398	4	2	RESISTOR 75 1% .125W F TC=0+-100	24546	C4-1/8-T0-75R0-F
A9R16	2100-2633	5		RESISTOR-TRMR 1K 10% C SIDE-ADJ 1-TRN	30983	ET50X102
A9R17	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A9R18	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A9U1	1826-0607	6	1	IC-REGULATOR 7815A	28480	1826-0607
A9U2	1826-0527	9	1	IC 337 V RGLTR TO-220	27014	LM337T
A9VR1	1902-0952	6	1	DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	28480	1902-0952
A9VR2	1902-0176	6	1	DIODE-ZNR 47V 5% PD=1W IR=5UA	28480	1902-0176
	6040-0239	9		LUBRICANT-GREASE SIL	05820	120
A10	00438-60006	6	1	POWER SUPPLY INTERCONNECT ASSEMBLY	28480	00438-60006
A10C1	0180-3286	2	1	CAPACITOR-FXD .018+75-10% 15VDC AL	28480	0180-3286
A10C2	0180-3283	9	1	CAPACITOR-FXD 2200UF+75-10% 50VDC AL	28480	0180-3283
A10C3	0180-3282	8	1	CAPACITOR-FXD 680UF+100-10% 50VDC AL	28480	0180-3282
A10C4	0160-3638	6		CAPACITOR-FXD .22UF +80-20% 200VDC CER	28480	0160-3638
A10C5	0180-1743	2		CAPACITOR-FXD .1UF+-10% 35VDC TA	56289	150D104X9035A2
A10C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A10C7	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A10C8	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A10C9	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A10CR1	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A10CR2	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A10J1	1251-6855	9	1	CONNECTOR 8-PIN M POST TYPE	28480	1251-6855
A10J2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A10J3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A10J4	1251-3638	0	1	CONNECTOR 6-PIN M POST TYPE	28480	1251-3638
A10MP1	0515-0054	7		SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A10MP2	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A10MP3	1205-0353	3		HEAT SINK SGL PLSTC-PWR-CS	13103	6073B
A10MP4				NOT ASSIGNED		
A10MP5				NOT ASSIGNED		
A10MP6	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A10MP7	2200-0103	2	1	SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	28480	2200-0103
A10MP8	3050-0105	6		WASHER-FL MTLC NO. 4 .125-IN-ID	28480	3050-0105
A10MP9	5040-0170	6	1	SUPPORT BOARD	28480	5040-0170
A10MP10	08673-20063	2		BUSHING	28480	08673-20063
A10TP1	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A10U1	1826-0147	9	1	IC 7812 V RGLTR TO-220	04713	MC7812CP
A10W1	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A10XA8	1251-2026	8	2	CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS	28480	1251-2026
A10XA9	1251-2026	8		CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS	28480	1251-2026
	6040-0239	9		LUBRICANT-GREASE SIL	05820	120
A11	00438-60007	7	1	HP-IB ASSEMBLY	28480	00438-60007
A11J1	1251-4833	9		CONNECTOR 34-PIN M POST TYPE	28480	1251-4833
A11J2	1251-3283	1	1	CONNECTOR 24-PIN F MICRORIBBON	28480	1251-3283
A11MP1	0380-0643	3	2	STANDOFF-HEX .255-IN-LG 6-32THD	00000	ORDER BY DESCRIPTION
A11MP2	0380-0643	3		STANDOFF-HEX .255-IN-LG 6-32THD	00000	ORDER BY DESCRIPTION
A11MP3	0515-0054	7		SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A11MP4	0515-0054	7		SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A11MP5	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A11MP6	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A11MP7	1530-1098	4	2	CLEVIS 0.070-IN W SLT: 0.454-IN PIN CTR,	00000	ORDER BY DESCRIPTION
A11MP8	1530-1098	4		CLEVIS 0.070-IN W SLT: 0.454-IN PIN CTR	00000	ORDER BY DESCRIPTION
A11MP9	2190-0019	6	2	WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0019
A11MP10	2190-0019	6		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0019
A11MP11	2190-0017	4	6	WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
A11MP12	2190-0017	4		WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
A11S1	3101-1973	7	1	SWITCH-SL 7-1A DIP-SLIDE-ASSY .1A 50VDC	28480	3101-1973
				CHASSIS PARTS		
G1	00436-60010	0	2	50MHZ POWER REFERENCE OSCILLATOR ASSEMBLY (STANDARD)	28480	00436-60010
G1A1	00436-60011	1	2	50MHZ POWER REFERENCE OSCILLATOR ASSY	28480	00436-60011
G1A1C1	0160-3879	7	4	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
G1A1C2	0160-3036	8	2	CAPACITOR-FDTHRU 5000PF +80 -20% 200V	28480	0160-3036
G1A1C3	0160-3036	8		CAPACITOR-FDTHRU 5000PF +80 -20% 200V	28480	0160-3036
G1A1C4	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
G1A1C5	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
G1A1C6	0160-2207	3	1	CAPACITOR-FXD 300PF +-5% 300VDC MICA	28480	0160-2207
G1A1C7	0160-2204	0	1	CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
G1A1C8	0180-0100	3	1	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	56289	150D475X9035B2
G1A1C9	0160-2255	1	1	CAPACITOR-FXD 8.2PF +-.25PF 500VDC CER	28480	0160-2255
G1A1C10	0160-3878	6	1	CAPACITOR-FXD 1000PF +-20% 100VDC CER	28480	0160-3878
G1A1C11	0160-2150	5	1	CAPACITOR-FXD 33PF +-5% 300VDC MICA	28480	0160-2150
G1A1C12	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
G1A1C13	0160-4006	4	1	CAPACITOR-FXD 36PF +-5% 300VDC GL	28480	0160-4006
G1A1C14	0160-4007	5	1	CAPACITOR-FXD 200PF +-5% 300VDC GL	28480	0160-4007
G1A1CR1	1901-0518	8	2	DIODE-SM SIG SCHOTTKY	28480	1901-0518
G1A1CR2	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
G1A1CR3	0122-0299	9	1	DIODE-VVC 82PF 5% C2/C20-MIN=2 BVR=20V	28480	0122-0299
G1A1J1	1250-1220	0	1	CONNECTOR-RF SMC M PC 50-OHM	28480	1250-1220
G1A1L1	00438-80001	3		COIL-VARIABLE	28480	00438-80001
G1A1L2	9140-0144	0	1	INDUCTOR RF-CH-MLD 4.7UH 10% .105DX.26LG	28480	9140-0144
G1A1L3	00436-80002	2	1	COIL-3-1/2 TURNS	28480	00436-80002
G1A1MP1	2190-0008	3	4	WASHER-LK EXT T NO. 6 .141-IN-ID	28480	2190-0008
G1A1MP2	2190-0009	4	8	WASHER-LK INTL T NO. 8 .168-IN-ID	28480	2190-0009
G1A1MP3	2190-0124	4	1	WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0124
G1A1MP4	2360-0209	7	4	SCREW-MACH 6-32 1-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
G1A1MP5	2580-0002	4	8	NUT-HEX-DBL-CHAM 8-32-THD .085-IN-THK	28480	2580-0002

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
G1A1MP6	2950-0078	9	1	NUT-HEX-DBL-CHAM 10-32-THD .067-IN-THK	28480	2950-0078
G1A1MP7	3050-0079	3		WASHER-FL NM NO. 2 .094-IN-ID .188-IN-OD	28480	3050-0079
G1A1MP8	7100-1204	9	1	CAN-RECT .72-IN-DP-OUT 1.959-IN-WD-OUT	28480	7100-1204
G1A1Q1	1854-0247	9	1	TRANSISTOR NPN SI TO-39 PD=1W FT=800MHZ	28480	1854-0247
G1A1Q2	1854-0071	7	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
G1A1R1	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
G1A1R2*	0757-1094	9	5	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
G1A1R3	0811-3234	9	1	RESISTOR 10K 1% .05W PWW TC=0+-10	20940	140-1/20-1002-F
G1A1R4	2100-3154	7	1	RESISTOR-TRMR 1K 10% C SIDE-ADJ 17-TRN	02111	43P102
G1A1R5	0811-3381	7	1	RESISTOR 7.1K 1% .05W PWW TC=0+-10	28480	0811-3381
G1A1R6	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
G1A1R7	0698-7284	5	2	RESISTOR 100K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1003-F
G1A1R8	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
G1A1R9	0698-7284	5		RESISTOR 100K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1003-F
G1A1R10	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
G1A1R11	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
G1A1R12	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
G1A1R13	0757-0438	3	1	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
G1A1R14	0757-0398	4		RESISTOR 75 1% .125W F TC=0+-100	24546	C4-1/8-T0-75R0-F
G1A1R15	0757-0317	7		RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F
G1A1R16	0698-6364	0	1	RESISTOR 50 .1% .125W F TC=0+-25	28480	0698-6364
G1A1TP1	0360-1514	7	2	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
G1A1TP2	0360-1514	7		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
G1A1U1	1826-0013	8	1	IC OP AMP LOW-NOISE TO-99 PKG	06665	SSS741CJ
G1A1U2	1820-0223	0	1	IC OP AMP GP TO-99 PKG	3L585	CA301AT
G1A1VR1	1902-0680	7		DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	24046	1N827
G1A1VR2*	1902-0956	0	1	DIODE-ZNR 8.2V 5% DO-35 PD=.4W TC=+.065%	28480	1902-0956
G2	00436-60010	0		50MHZ POWER REFERENCE OSCILLATOR ASSEMBLY (OPTION 002)	28480	00436-60010
G2A1	00436-60011	1		REPEAT PARTS OF G1A1 FOR G2A1 (OPT 002)	28480	00436-60011
B1	3160-0266	3	1	FAN-TBAX 36-CFM 6-16VDC	28480	3160-0266
C1	0160-4065	5	1	CAPACITOR-FXD .1UF +-20% 250VAC(RMS)	28480	0160-4065
C2	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
F1	2110-0001	8	1	FUSE 1A 250V NTD 1.25X.25 UL	75915	312001
F1	2110-0012	1	1	FUSE .5A 250V NTD 1.25X.25 UL	28480	2110-0012
G3	3160-0310	8	1	MODULE-MOTOR CONTROL SPEED CONTROL FOR	D3976	3.431.036.01
J1				NSR, P/O W3		
J2				NSR, P/O W1		
J3				NSR, P/O W2		
J4				NSR, P/O W13 ONLY OPT.		
J5				NSR, P/O W14 ONLY OPT.		
J6				NSR, P/O W15 ONLY OPT.		
J7	1250-0083	1	1	CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	28480	1250-0083
MP1	5020-8813	8	1	FRAME FRONT	28480	5020-8813
MP2	00438-00005	9	1	PANEL FRONT	28480	00438-00005
MP3	00438-20024	4	1	FRAME REAR	28480	00438-20024
MP4	5040-7203	0	1	TRIM STRIP	28480	5040-7203
MP5	5001-0438	7	2	TRIM SIDE 3 1/2	28480	5001-0438

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
MP6	5061-0014	1	1	COVER U SHAPE	28480	5061-0014
MP7	5060-9964	6	1	COVER BOTTOM	28480	5060-9964
MP8-MP12				NOT ASSIGNED		
MP13	1460-1345	5	2	TILT STAND SST	28480	1460-1345
MP14	00438-00003	7	1	PANEL REAR	28480	00438-00003
MP15	5040-7201	8	4	FOOT FULL 1/2 MOD	28480	5040-7201
MP16	00438-00004	8	1	SHIELD FAN	28480	00438-00004
MP17	0515-0252	7	4	SCREW-MACH M3 X 0.5 40MM-LG PAN-HD	28480	0515-0252
MP18	3050-0105	6		WASHER-FL MTLC NO. 4 .125-IN-ID	28480	3050-0105
MP19	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
MP20	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
MP21	2190-0016	3	1	WASHER-LK INTL T 3/8 IN .377-IN-ID PART OF J7	28480	2190-0016
MP22	2950-0043	8	1	NUT-HEX-DBL-CHAM 3/8-32-THD .094-IN-THK PART OF J7	00000	ORDER BY DESCRIPTION
MP23	6960-0009	1	1	PLUG-HOLE FL-HD FOR .438-D-HOLE BRS EXCEPT OPT. 002	28480	6960-0009
MP24	6960-0024	0	1	PLUG-HOLE FL-HD FOR .688-D-HOLE NYL	28480	6960-0024
MP25	5020-8831	0	2	SIDE STRUTS	28480	5020-8831
MP26-MP32				NOT ASSIGNED		
MP33	00438-00012	8	2	SUPPORT CABLE	28480	00438-00012
MP34-MP35				NOT ASSIGNED		
MP36	00438-00006	0	1	PANEL SUB	28480	00438-00006
MP37	00438-20020	0	1	SCREEN RFI	28480	00438-20020
MP38	00438-20023	3	1	WINDOW	28480	00438-20023
MP39	5040-6889	6	1	LIGHT PIPE 19MM	28480	5040-6889
MP40				NOT ASSIGNED		
MP41	00438-20032	4	1	SUPPORT BOTTOM (WINDOW)	28480	00438-20032
MP42	00438-20033	5	1	SUPPORT TOP S PNL	28480	00438-20033
MP43	00438-00012	8		SUPPORT CABLE FR PNL	28480	00438-00012
MP44	2190-0104	0	2	WASHER-LK INTL T 7/16 IN .439-IN-ID OPT 002 ONLY PART OF J1 & J6	28480	2190-0104
MP45	2950-0132	6	4	NUT-HEX-DBL-CHAM 7/16-28-THD .094-IN-THK OPT 002 ONLY PART OF J1 & J6	00000	ORDER BY DESCRIPTION
MP46	00436-20014	0	4	WASHER MOUNT CONN (PART OF J2 AND J3) J4 AND J5 (OPT. 002 ONLY)	28480	00436-20014
MP47	1251-3362	7	4	NUT-AUDIO CONN OPT 002 ONLY PART OF J2 & J3	28480	1251-3362
MP48	0510-1149	3	5	RETAINER-PUSH ON KB-TO-SHFT EXT PART OF WINDOW	28480	0510-1149
MP49	7120-3104	4	6	WIRE MARKER SGL-LTR=A PLSTC-SPR-CLP PVC	06229	C8P-LETTER A
MP50	7120-3105	5	6	WIRE MARKER SGL-LTR=B PLSTC-SPR-CLP PVC OPT 002 ONLY EXCEPT OPT 004	06229	C8P-LETTER B
MP51	0515-0410	9	4	SCREW-MACH M3 X 0.5 20MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
MP52	2200-0164	5	3	SCREW-MACH 4-40 .188-IN-LG UNCT 82 DEG	00000	ORDER BY DESCRIPTION
MP53	2200-0166	7	8	SCREW-MACH 4-40 .312-IN-LG 82 DEG	00000	ORDER BY DESCRIPTION
MP54	5041-1682	9	1	KEY CAP LINE	28480	5041-1682
MP55	0362-0227	1	2	CONNECTOR-SGL CONT SKT 1.14-MM-BSC-SZ	28480	0362-0227
MP56				NOT ASSIGNED		
MP57	0360-1190	5	1	TERMINAL-SLDR LUG PL-MTG FOR-#3/8-SCR	28480	0360-1190
MP58-MP74				NOT ASSIGNED		
MP75	00438-00001	5	1	DECK	28480	00438-00001
MP76	00438-20031	3	1	BOARD SUPPORT	28480	00438-20031
MP77	00438-20026	6	1	PUSHROD	28480	00438-20026
MP78	00438-20025	5	1	CLIP PUSHROD	28480	00438-20025
MP79	00438-00009	3	1	SUPPORT AMPLIFIER	28480	00438-00009
MP80				NOT ASSIGNED		
MP81	7120-4163	7	1	LABEL-WARNING .5-IN-WD 1-IN-LG AL	28480	7120-4163
MP82	00438-00002	6	1	SHIELD INPUT AMP	28480	00438-00002
MP83	0515-0356	2	8	SCREW-MACHINE ASSEMPLY M3.5 X 0.6	00000	ORDER BY DESCRIPTION
MP84	0515-0101	5	8	SCREW-MACH M3 X 0.5 22MM-LG PAN-HD	28480	0515-0101
MP85	0515-0211	8	25	SCREW-MACH M3 X 0.5 6MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
MP86	0515-0212	9	10	SCREW-MACH M3.5 X 0.6 6MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
MP87	0515-0226	5	2	SCREW-MACH M2.5 X 0.45 6MM-LG PAN-HD	00000	ORDER BY DESCRIPTION

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
MP88	0515-0306	2	4	SCREW-MACH M4 X 0.7 40MM-LG PAN-HD	28480	0515-0306
MP89	0515-0389	1	4	SCREW-MACHINE ASSEMPLY M3.5 X 0.6 8MM-LG	00000	ORDER BY DESCRIPTION
MP90	0515-0409	6	2	SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
MP91	2200-0164	5		SCREW-MACH 4-40 .188-IN-LG UNCT 82 DEG OPT 002 ONLY FOR CABLE SUPPORT BRACKET	00000	ORDER BY DESCRIPTION
MP92	2360-0117	6	5	SCREW-MACH 6-32 .375-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
MP93	2360-0181	4	6	SCREW-MACH 6-32 .25-IN-LG 82 DEG	00000	ORDER BY DESCRIPTION
MP94	2510-0192	6	8	SCREW-MACH 8-32 .25-IN-LG 100 DEG	00000	ORDER BY DESCRIPTION
MP95	0535-0007	2	1	NUT-HEX DBL-CHAM M3.5 X 0.6 2.8MM-THK	00000	ORDER BY DESCRIPTION
MP96				NOT ASSIGNED		
MP97				NOT ASSIGNED		
MP98	2190-0017	4		WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
MP99	1400-0053	4	1	CLAMP-CABLE .172-DIA .375-WD NYL	28480	1400-0053
MP100	1400-0510	8	2	CLAMP-CABLE .15-DIA .62-WD NYL OPTION 002 ONLY	28480	1400-0510
MP110	0515-0101	5		SCREW-MACH M3 X 0.5 22MM-LG PAN-HD	28480	0515-0101
S1	00438-60041	9	1	SWITCH PUSHBUTTON LINE ON OFF KIT	28480	00438-60041
T1	9100-4342	4	1	TRANSFORMER	28480	9100-4342
U1	0960-0443	1	1	LINE MODULE-FILTERED	28480	0960-0443
W1	00438-60020	4	2	CABLE ASSY FRONT A	28480	00438-60020
W2	00438-60020	4		CABLE ASSY FRONT B	28480	00438-60020
W3	00438-60026	0	2	CABLE ASSY REF OSC (PART OF J1) FROM G1 50MHZ REFERENCE OSCILLATOR TO J1 FRONT PANEL	28480	00438-60026
W4	00438-60033	9	1	CABLE ASSY KEYS FROM A3J4 TO A1 (60001)	28480	00438-60033
W5	00438-60031	7	1	CABLE ASSY DISPLAY FROM A3J5 TO A2J1	28480	00438-60031
W6	00438-60034	0		CABLE ASSY MICRO FROM A3J3 TO A5J2 (MAIN AMPLIFIER)	28480	00438-60034
W7	00438-60032	8	1	CABLE ASSY HP-IB FROM A3J1 TO A11 (60007) HP/IB	28480	00438-60032
W8	00438-60038	4	1	LINE SWITCH ASSY FROM S1 TO U1 (LINE MOD FILTER) & C1	28480	00438-60038
W9	00438-60027	1	1	W HRNS REDR-OUPT REAR PANEL BNC J7 TO A5J1 & LUG HAS GND	28480	00438-60027
W10	00438-60040	8	1	CABLE ASSY AMP SIG FROM A4J6 TO A5J4	28480	00438-60040
W11	00438-60035	1	1	CABLE ASSY ANALOG INP FROM A4J10 AMP INPUT TO A5J3 MAIN AMP	28480	00438-60035
W12	8120-1378	1	1	CABLE ASSY 18AWG 3-CNDCT JGK-JKT	28480	8120-1378
W13	00438-60022	6	2	CABLE ASSY REAR A PART OF J4 OPT 002 ONLY	28480	00438-60022
W14	00438-60022	6		CABLE ASSY REAR B PART OF J5 OPT 002 ONLY	28480	00438-60022
W15	00438-60026	0		CABLE ASSY REF OSC PART OF J6 OPT 002 ONLY	28480	00438-60026
W16	00438-60036	2	1	WIRING HARNESS FROM A10J1 INTERCONNECT TO A3J2, J6 MICROPROCESSOR & A4J2 INPUT AMPLIFIER	28480	00438-60036

See introduction to this section for ordering information
*Indicates factory selected value

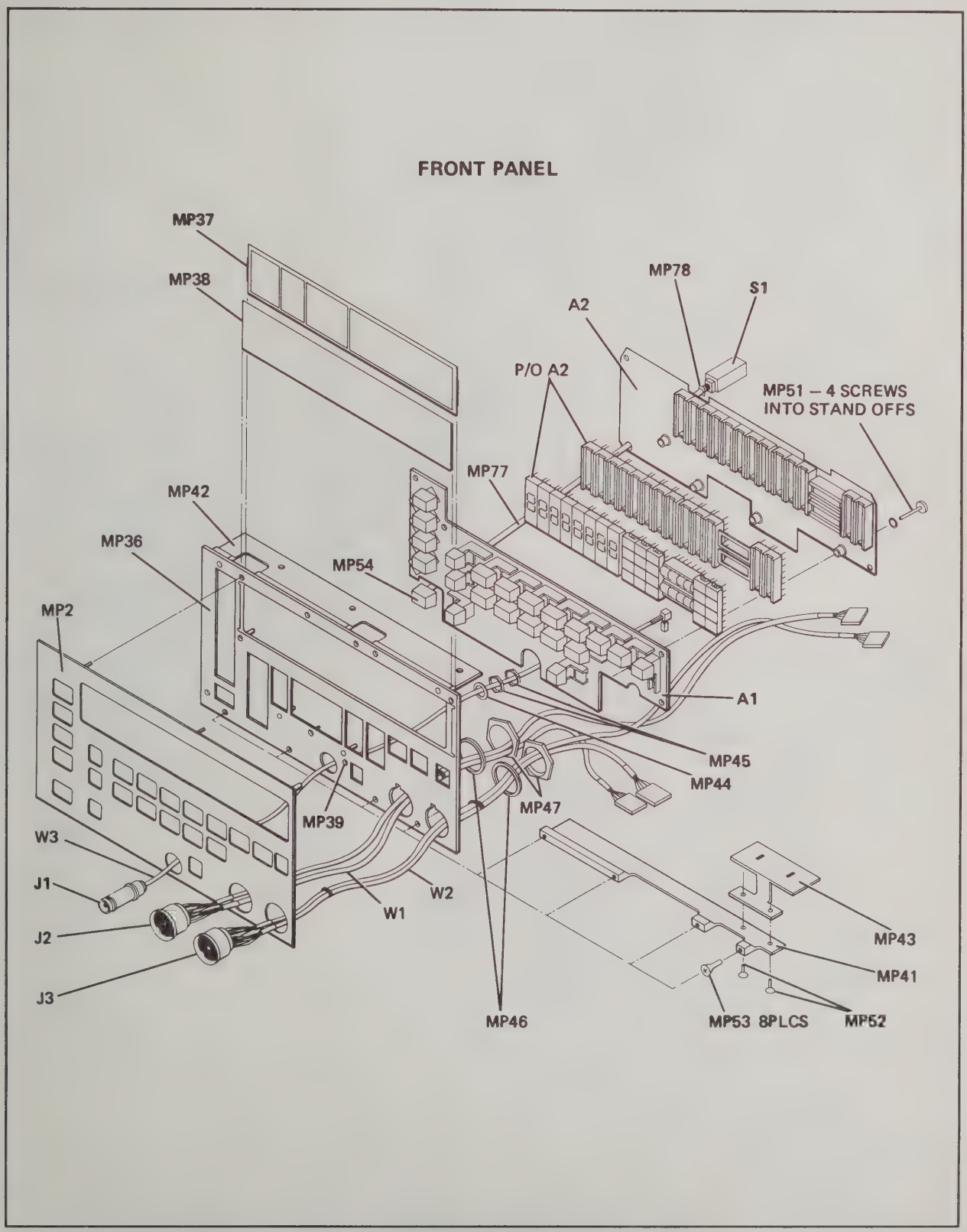


Figure 6-1. Front Panel Illustrated Parts Breakdown

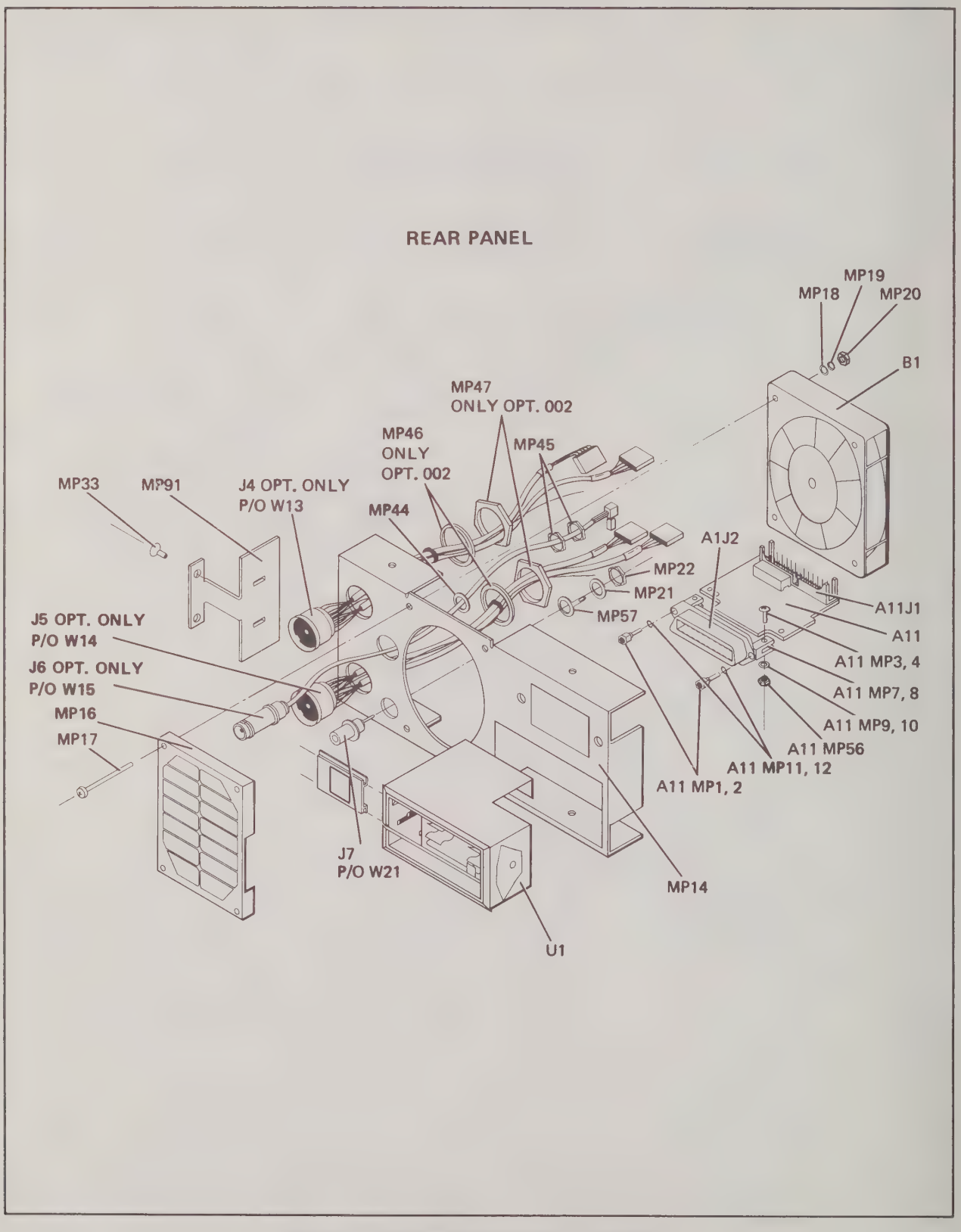


Figure 6-2. Rear Panel Illustrated Parts Breakdown

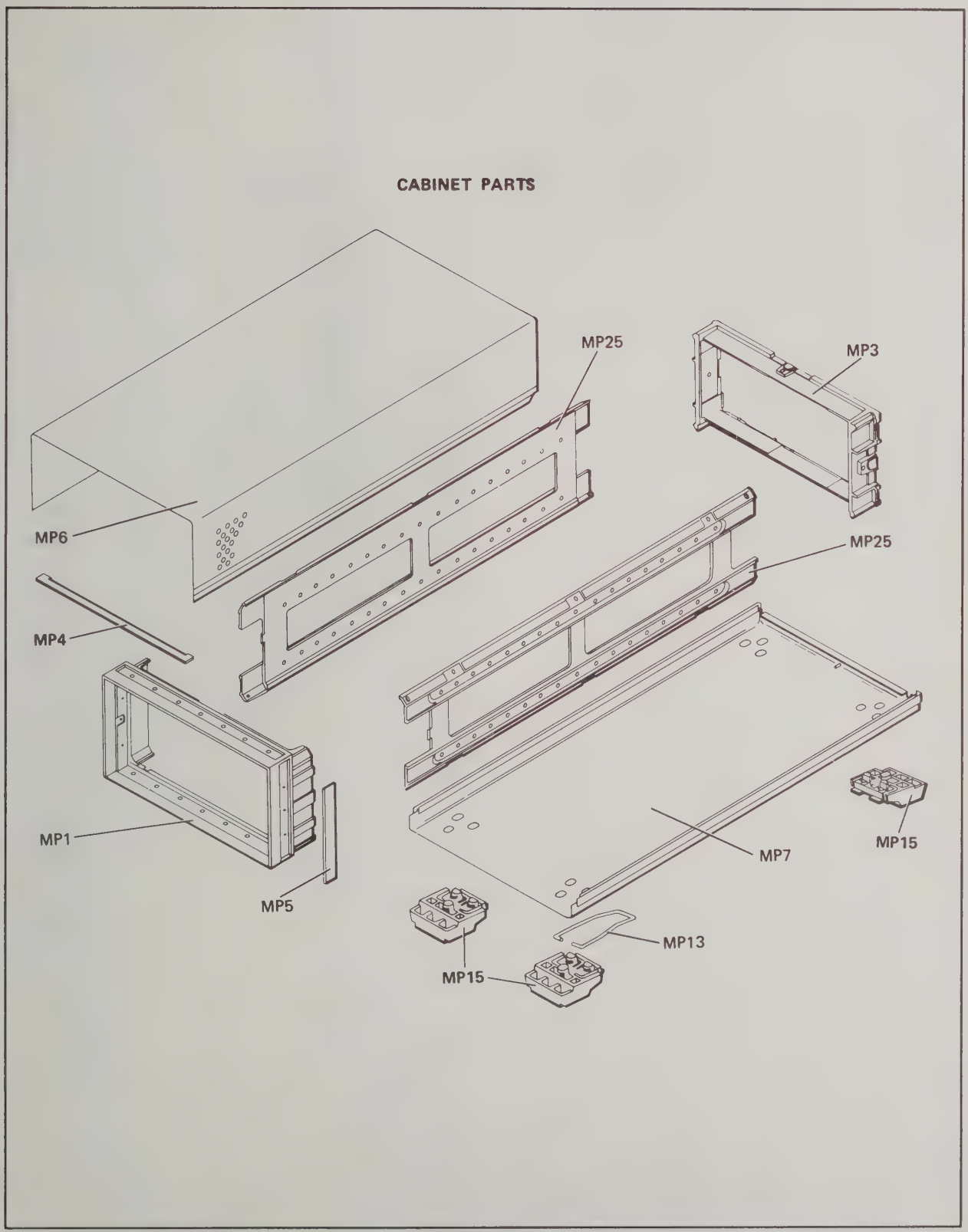


Figure 6-3. Cabinet Parts

Table 6-4. Code List of Manufacturers

Mfr Code	Manufacturer Name	Address		Zip Code
D3976	BUEHLER GEBR NACHFOLGER GMBH	NURNBERG	GM	7750
S0545	NIPPON ELECTRIC CO	TOKYO	JP	
00000	ANY SATISFACTORY SUPPLIER			
01121	ALLEN-BRADLEY CO	MILWAUKEE	WI	53204
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	DALLAS	TX	75222
02111	SPECTROL ELECTRONICS CORP	CITY OF IND	CA	91745
03888	K D I PYROFILM CORP	WHIPPANY	NJ	07981
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHOENIX	AZ	85008
05820	WAKEFIELD ENGINEERING INC	WAKEFIELD	MA	01880
06001	MEPCO ELECTRA CORP	COLUMBIA	SC	29063
06229	ELECTROVERT INC	ELMSFORD	NY	10553
06665	PRECISION MONOLITHICS INC	SANTA CLARA	CA	95050
07263	FAIRCHILD SEMICONDUCTOR DIV	MOUNTAIN VIEW	CA	94042
13103	THERMALLOY CO	DALLAS	TX	75234
13606	SPRAGUE ELECT CO SEMICONDUCTOR DIV	CONCORD	NH	03301
16299	CORNING GLASS WKS COMPONENT DIV	RALEIGH	NC	27604
19701	MEPCO/ELECTRA CORP	MINERAL WELLS	TX	76067
20940	MICRO-OHM CORP	EL MONTE	CA	91731
24046	TRANSITRON ELECTRONIC CORP	WAKEFIELD	MA	01880
24355	ANALOG DEVICES INC	NORWOOD	MA	02062
24546	CORNING GLASS WORKS (BRADFORD)	BRADFORD	PA	16701
25088	SIEMENS CORP	ISELIN	NJ	08830
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA	CA	95051
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO	CA	94304
3L585	RCA CORP SOLID STATE DIV	SOMERVILLE	NJ	
30983	MEPCO/ELECTRA CORP	SAN DIEGO	CA	92121
34344	MOTOROLA INC	FRANKLIN PARK	IL	60131
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS	MA	01247
73138	BECKMAN INSTRUMENTS INC HELIPOT DIV	FULLERTON	CA	92634
75915	LITTELFUSE INC	DES PLAINES	IL	60016

SECTION VII
MANUAL CHANGES

7-1. INTRODUCTION

This section normally contains information for adapting this manual to instruments for which the content does not apply directly. Since this manual does apply directly to instruments having serial numbers listed on the title page, no change information is given here. Refer to paragraph 1-4, Instruments Covered by this Manual, for additional important information about serial number coverage.

SECTION VIII
SERVICE

8-1. INTRODUCTION

This section contains information required for servicing the Power Meter. It includes block diagrams with theory and troubleshooting, schematic diagrams, schematic diagram notes, and after service safety checks.

8-2. SERVICE SHEETS

The foldout pages in the last part of this section are called the service sheets (SS). They contain block diagrams, schematic diagrams, supplemental diagrams, and associated information.

8-3. Block Diagrams

The block diagrams and related service information are found on Service Sheets BD1, BD2 and BD3. BD1 is an overall block diagram that shows the major functional sections of the Power Meter. It serves as an index to the more detailed information on the succeeding service sheets and is the starting point for most troubleshooting procedures. BD2 shows the Controller Section with connections to BD3 the Amplifier Section.

8-4. Schematic Diagrams

The schematic diagrams and their associated information are presented in Service Sheets 1 through 11. These diagrams, in functional groupings, are designed to aid in understanding the principles of operation and to aid in troubleshooting the Power Meter. Refer to the paragraph entitled Troubleshooting for additional information.

8-5. SAFETY CONSIDERATIONS

8-6. Before Applying Power

Verify that the instrument is properly set to operate from the available line voltage and that the correct fuse is installed. An uninterrupted safety earth ground must be provided from the main power source to the instrument input wiring terminals, power cord, or supplied power cord set.

8-7. Warnings and Cautions

Pay attention to the WARNINGS and CAUTIONS. They must be followed for your protection and to avoid damage to the equipment.

WARNINGS

Maintenance described herein must be performed with power supplied to the instrument and with protective covers removed. Such maintenance should be performed only by service trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

Any interruption of the protective (grounding) conductor (inside or outside of the instrument) or disconnection of the protective earth terminal will create a potential shock hazard and could result in personal injury. Grounding one conductor of a two-conductor outlet is not sufficient. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative (i.e., secured against unintended operation).

If the instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

Capacitors inside the instrument may still be charged even if the instrument is disconnected from the power source.

Make sure that only 250 volt normal-blow fuses with the specified current rating are used for replacement. Do not use repaired fuses or short-circuited fuseholders. To do so could create a shock or fire hazard.

CAUTIONS

Some printed circuit boards contain devices that may be damaged if the board is removed or installed while the power is on. Verify that the LINE switch is OFF or that the power cord is unplugged before you remove or install a printed circuit board.

CAUTIONS (cont'd)

After removing MOS devices from sockets, store the devices with the pins in conductive foam. This will prevent accidental damage from a static discharge.

8-8. RECOMMENDED TEST EQUIPMENT AND ACCESSORIES

Test equipment and test accessories required to maintain the Power Meter are listed in Table 1-3, Recommended Test Equipment. Equipment other than that listed may be used if it meets the critical specifications listed.

8-9. SERVICE TOOLS, AIDS, AND INFORMATION

8-10. Service Tools

Equipment recommended for use when changing components on printed circuit boards is listed in Table 8-1. The following unique service tools will make servicing of this instrument much easier.

Pozidriv Screwdrivers. Many screws in the Power Meter appear to be Phillips type, but they are not. To avoid damage to the screw heads, Pozidriv screwdrivers should be used. The Pozidriv No.1 size can be ordered as HP part number 8710-0899, and the Pozidriv No. 2 size can be ordered as HP part number 8710-0900.

Tuning Tools. For adjustments requiring non-metallic tuning tools, use the blade tuning tool HP part number 8710-0033 or hex tuning tool(JFD Model No. 5284) HP part number 8710-1010. For other adjustments, an ordinary small screwdriver is sufficient. No matter which tool is used, never force any adjustment control against its stops. This is especially critical when adjusting variable inductors or capacitors.

Heat Staking Tool. The front-panel pushbutton switches have small plastic pins that protrude through the printed circuit board, and the pins are then flattened with a heated tool that softens the plastic. The heat staking tool is a standard soldering iron with a special tip attached.

8-11. Assembly Locations

Printed circuit board assemblies are numbered sequentially from front to back. For example, A1 is part of the front panel assembly.

8-12. Parts and Cable Locations

The locations of individual components on the printed circuit boards and other assemblies are shown adjacent to the schematic diagrams on the appropriate Service Sheet. The complete reference designator consists of the assembly designator plus the part designator. For example, A6R9 is resistor R9 on the A6 assembly. For specific component descriptions and ordering information, refer to Table 6-3, Replaceable Parts. Chassis, frame, and other mechanical parts are identified in Figures 6-1 through 6-3.

Mechanical parts have reference designators that begin with the letters MP. Mechanical parts such as screws, washers, and nuts are listed in the replaceable parts list. To find the part number and description of a mechanical part, find the part in one of the figures in Section VI or Section VIII. The part in the figure will be labeled with its reference designator. Look up the reference designator in Table 6-3 Replaceable Parts.

The Power Meter has a mixture of Unified National (inch) and metric screws. The metric screws are defined by Industrial Fasteners publication (IFI 500) and are identified in the replaceable parts list as metric (M). Unified National screws have a dull steel gray appearance and the metric screws have a shiny silver appearance. Do not use a metric screw in a Unified National nut, thread damage will result.

8-13. Test Point and Adjustment Locations

Most test points and adjustments are indicated on individual circuit board assemblies. Test points and adjustments can also be found on the component locator diagrams adjacent to the assembly chematic diagrams.

8-14. Service Aids on Printed Circuit Boards

The service aids on the printed circuit boards include test points, indicator LEDs, reference designators, adjustment names, and assembly part numbers.

8-15. Other Service Documents

Service Notes, Manual Changes Supplements, Application Notes, and other service literature are available from Hewlett Packard. For further information, contact your nearest Hewlett Packard office.

Table 8-1. Etched Circuit Soldering Equipment

Item	Use	Specification	Item Recommended	HP Part No.
Soldering Tool	Soldering, Heat Staking	Wattage: 35W Tip Temp.: 390—440°C (735—825°F)	Ungar No. 135 Ungar Division Eldon Ind. Corp. Compton, CA 90220	8690-0167
Soldering Tip	Soldering, Unsoldering	*Shape: Chisel	*Ungar PL113	8690-0007
Soldering Tip	Heat Staking	Shape: Cupped	HP 5020-8160 or modified Ungar PL11	5020-8160
De-Solder Aid	To remove molten solder from connection	Suction Device	Soldapullt by Edsyn Co., Van Nuys, CA 91406	8690-0060
Rosin (flux) Solvent	To remove excess flux from soldered area before application of protective coating	Must not dissolve etched circuit base board.	Freon	8500-0232
Solder	Component replacement; Circuit Board repair wiring	Rosin (flux core, high tin content (63/37 tin/lead), 18 gauge (SWG) 0.048 in. diameter preferred.		8090-0607

*For working on circuit boards; for general purpose work, use No. 555 Handle (8690-0261) and No. 4037 Heating Unit 47½ — 56½ W (HP 8690-0006); tip temperature of 850 — 900°F; and Ungar No. PL113 ⅛" chisel tip.

8-16. TROUBLESHOOTING

8-17. Service Related Error Messages

The Power Meter generates error messages to indicate operating problems, incorrect keyboard entries or service related problems. The error message is generally cleared when the error condition is removed. Refer to Service Sheet 2 for further troubleshooting when a ROM or RAM error message appears.

Service error messages from the power up diagnostic are 61 through 66. These errors are displayed when a problem with ROM or RAM has been detected. A list of the errors follows:

61 A3U9 ROM address 8000H through 09FFFH
62 A3U9 ROM address 0A000H through 0BFFFH
63 A3U10 ROM address 0C000H through 0DFFFH
64 A3U10 ROM address 0E000H through 0FFFFH
65 A3U12 RAM address 800H through 0FFFH
66 A3U13 RAM address 0 through 7FFH

8-18. AFTER SERVICE SAFETY CHECKS

Visually inspect interior of instrument for any signs of abnormal internally generated heat, such as discolored printed circuit boards or components, damaged insulation, or evidence or arcing. Determine and remedy cause of any such condition.

Using a suitable ohmmeter, check resistance from instrument enclosure to ground pin on power cord plug. The reading must be less than one ohm. Flex the power cord while making this measurement to determine whether intermittent discontinuities exist.

Check any indicated front or rear panel ground terminals marked, using the above procedures.

Check resistance from instrument enclosure to line and neutral (tied together) with the power switch on and the power source disconnected. The minimum acceptable resistance is two megohms. Replace any component which results in a failure.

Check line fuse to verify that a correctly rated fuse is installed.

Table 8-2. Schematic Diagram Notes (1 of 8)

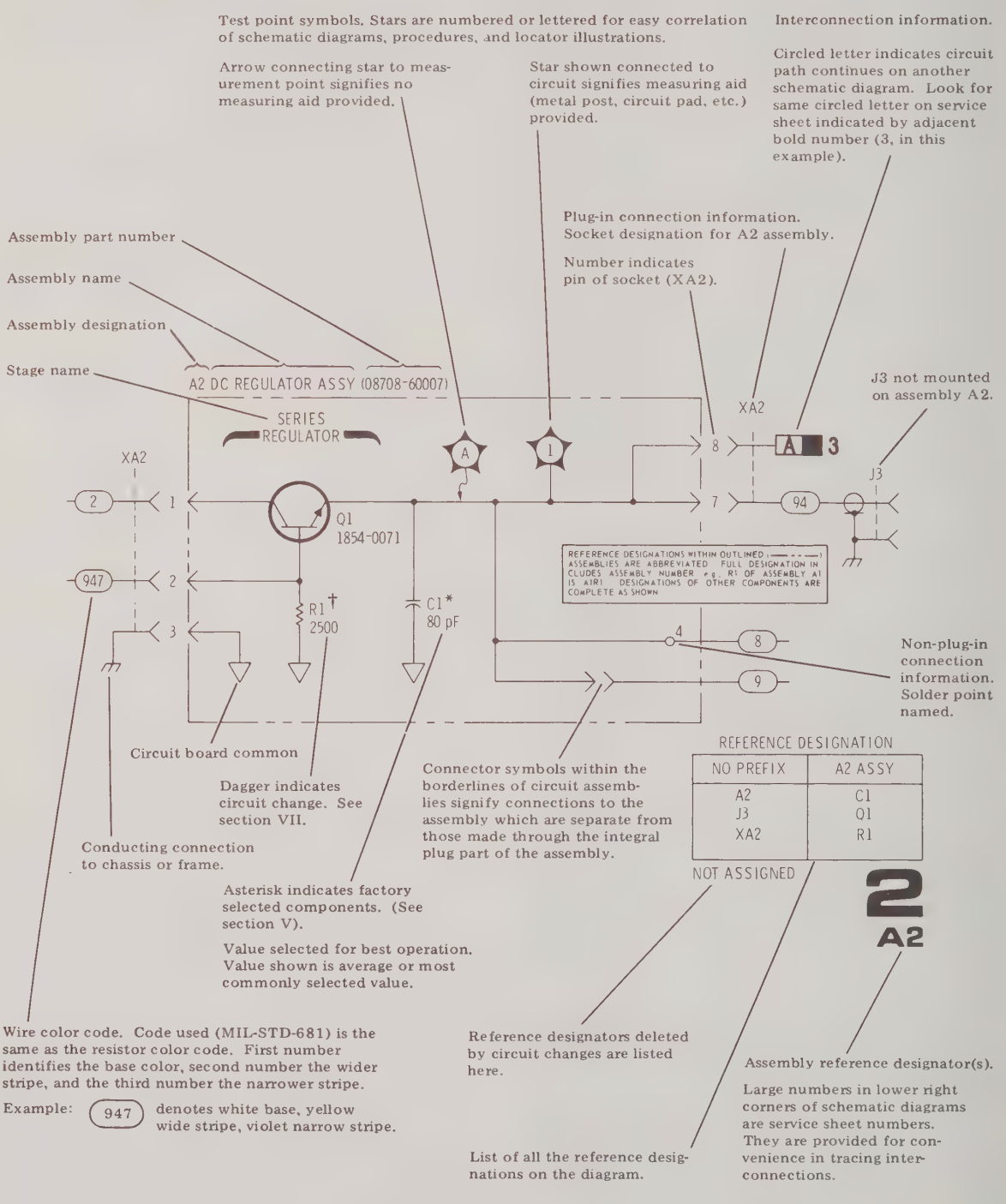

Test point symbols. Stars are numbered or lettered for easy correlation of schematic diagrams, procedures, and locator illustrations.
Arrow connecting star to measurement point signifies no measuring aid provided.
Star shown connected to circuit signifies measuring aid (metal post, circuit pad, etc.) provided.
Interconnection information.
Circled letter indicates circuit path continues on another schematic diagram. Look for same circled letter on service sheet indicated by adjacent bold number (3, in this example).
Plug-in connection information. Socket designation for A2 assembly.
Number indicates pin of socket (XA2).
Assembly part number
Assembly name
Assembly designation
Stage name
A2 DC REGULATOR ASSY (08708-60007)
SERIES REGULATOR
J3 not mounted on assembly A2.
XA2
J3
Q1
1854-0071
R1 †
2500
C1*
80 pF
REFERENCE DESIGNATIONS WITHIN OUTLINED ASSEMBLIES ARE ABBREVIATED. FULL DESIGNATION INCLUDES ASSEMBLY NUMBER e.g., R1 OF ASSEMBLY A1 IS A1R1. DESIGNATIONS OF OTHER COMPONENTS ARE COMPLETE AS SHOWN
Non-plug-in connection information. Solder point named.
Circuit board common
Dagger indicates circuit change. See section VII.
Connector symbols within the borderlines of circuit assemblies signify connections to the assembly which are separate from those made through the integral plug part of the assembly.
REFERENCE DESIGNATION
NO PREFIX
A2 ASSY
A2
J3
XA2
C1
Q1
R1
NOT ASSIGNED
Conducting connection to chassis or frame.
Asterisk indicates factory selected components. (See section V).
Value selected for best operation. Value shown is average or most commonly selected value.
Wire color code. Code used (MIL-STD-681) is the same as the resistor color code. First number identifies the base color, second number the wider stripe, and the third number the narrower stripe.
Example: 947 denotes white base, yellow wide stripe, violet narrow stripe.
Reference designators deleted by circuit changes are listed here.
List of all the reference designations on the diagram.
Assembly reference designator(s).
Large numbers in lower right corners of schematic diagrams are service sheet numbers. They are provided for convenience in tracing interconnections.

Table 8-2. Schematic Diagram Notes (2 of 8)

SCHEMATIC DIAGRAM NOTES

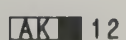
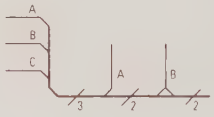
*	Asterisk denotes a factory-selected value. Value shown is typical.
†	Dagger indicates circuit change. See Section VII.
	Tool-aided adjustment. Manual control.
	Encloses front-panel designation.
	Encloses rear-panel designation.
	Circuit assembly borderline.
	Other assembly borderline.
	Heavy line with arrows indicates path and direction of main signal.
	Heavy dashed line with arrows indicates path and direction of main feedback.
	Indicates stripline (i.e., RF transmission line above ground).
	Wiper moves toward cw with clockwise rotation of control (as viewed from shaft or knob).
	Numbered Test Point measurement aid provided.
	Encloses wire or cable color code. Code used is the same as the resistor color code. First number identifies the base color, second number identifies the wider stripe, and the third number identifies the narrower stripe, e.g., denotes white base, yellow wide stripe, violet narrow stripe.
	A direct conducting connection to earth, or a conducting connection to a structure that has a similar function (e.g., the frame of an air, sea, or land vehicle).
	A conducting connection to a chassis or frame.
	Common connections. All like-designation points are connected.
	Letters = off-page connection, e.g., AK Number = Service Sheet number for off-page connection, e.g., 12
	Number (only) = on-page connection.

Table 8-2. Schematic Diagram Notes (3 of 8)

SCHEMATIC DIAGRAM NOTES



Indicates multiple paths represented by only one line. Letters or names identify individual paths. Numbers indicate number of paths represented by the line.

Coaxial or shielded cable.

Relay. Contact moves in direction of arrow when energized.

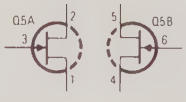
Indicates a pushbutton switch with a momentary (ON) position.

Indicates a PIN diode.

Indicates a current regulation diode.

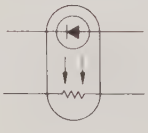
Indicates a voltage regulation diode.

Indicates a Schottky (hot-carrier) diode.



Multiple transistors in a single package—physical location of the pins is shown in package outline on schematic.

Identification of logic families as shown (in this case, ECL).

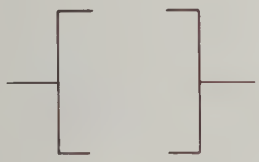


Indicates an opto-isolator of a LED and a photoresistor packaged together. The resistance of the photoresistor is a function of the current flowing through the LED.

Table 8-2. Schematic Diagram Notes (4 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Input and Output Indicators



Implied Indicator—Absence of polarity indicator (see below) implies that the active state is a relative high voltage level. Absence of negation indicator (see below) implies that the active state is a relative high voltage level at the input or output.

Polarity Indicator—The active state is a relatively low voltage level.

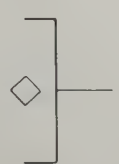
Dynamic Indicator—The active state is a transition from a relative low to a relative high voltage level.

Inhibit Input—Input that, when active, inhibits (blocks) the active state outputs of a digital device.

Analog Input—Input that is a continuous signal function (e.g., a sine wave).

Polarity Indicator used with Inhibit Indicator—Indicates that the relatively low level signal inhibits (blocks) the active state outputs of a digital device.

Output Delay—Binary output changes state only after the referenced input (m) returns to its inactive state (m should be replaced by appropriate dependency or function symbols).



Open Collector Output—Output that must form part of a distributed connection.

Table 8-2. Schematic Diagram Notes (5 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Input and Output Indicators (Cont'd)

3-STATE	Three-state Output—Indicates outputs that can have a high impedance (disconnect) state in addition to the normal binary logic states.

Combinational Logic Symbols and Functions

&	AND—All inputs must be active for the output to be active.
≥1	OR—One or more inputs being active will cause the output to be active.
≥m	Logic Threshold—m or more inputs being active will cause the output to be active (replace m with a number).
=1	EXCLUSIVE OR—Output will be active when one (and only one) input is active.
=m	m and only m—Output will be active when m (and only m) inputs are active (replace m with a number).
=	Logic Identity—Output will be active only when all or none of the inputs are active (i.e., when all inputs are identical, output will be active).
	Amplifier—The output will be active only when the input is active (can be used with polarity or logic indicator at input or output to signify inversion).
X/Y	Signal Level Converter—Input level(s) are different than output level(s).
	Bilateral Switch—Binary controlled switch which acts as an on/off switch to analog or binary signals flowing in both directions. Dependency notation should be used to indicate affecting/affected inputs and outputs. Note: amplifier symbol (with dependency notation) should be read to indicate unilateral switching.
X→Y	Coder—Input code (X) is converted to output code (Y) per weighted values or a table.
(Functional Labels)	The following labels are to be used as necessary to ensure rapid identification of device function.
MUX	Multiplexer—The output is dependent only on the selected input.
DEMUX	Demultiplexer—Only the selected output is a function of the input.
CPU	Central Processing Unit
PIO	Peripheral Input/Output
SMI	Static Memory Interface

Table 8-2. Schematic Diagram Notes (6 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Sequential Logic Functions

1	Monostable—Single shot multivibrator. Output becomes active when the input becomes active. Output remains active (even if the input becomes inactive) for a period of time that is characteristic of the device and/or circuit.
G	Oscillator—The output is a uniform repetitive signal which alternates between the high and low state values. If an input is shown, then the output will be active if and only if the input is in the active state.
FF	Flip-Flop—Binary element with two stable states, set and reset. When the flip-flop is set, its outputs will be in their active states. When the flip-flop is reset, its outputs will be in their inactive states.
T	Toggle Input—When active, causes the flip-flop to change states.
S	Set Input—When active, causes the flip-flop to set.
R	Reset Input—When active, causes the flip-flop to reset.
J	J Input—Analogous to set input.
K	K Input—Analogous to reset input.
D	Data Input—Always enabled by another input (generally a C input—see Dependency Notation). When the D input is dependency-enabled, a high level at D will set the flip-flop; a low level will reset the flip-flop. Note: strictly speaking, D inputs have no active or inactive states—they are just enabled or disabled.
m	Count-Up Input—When active, increments the contents (count) of a counter by "m" counts (m is replaced with a number).
−m	Count-Down Input—When active, decrements the contents (count) of a counter by "m" counts (m is replaced with a number).
→ m	Shift Right (Down) Input—When active, causes the contents of a shift register to shift to the right or down "m" places (m is replaced with a number).
← m	Shift Left (Up) Input—When active, causes the contents of a shift register to shift to the left or up "m" places (m is replaced with a number).

NOTE

For the four functions shown above, if m is one, it is omitted.

(Functional Labels)	The following functional labels are to be used as necessary in symbol build-ups to ensure rapid identification of device function.

Table 8-2. Schematic Diagram Notes (7 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Sequential Logic Functions (Cont'd)

mCNTR	Counter—Array of flip-flops connected to form a counter with modulus m (m is replaced with a number that indicates the number of states: 5 CNTR, 10 CNTR, etc.).
REG	Register—Array of unconnected flip-flops that form a simple register or latch.
SREG	Shift Register—Array of flip-flops that form a register with internal connections that permit shifting the contents from flip-flop to flip-flop.
ROM	Read Only Memory—Addressable memory with read-out capability only.
RAM	Random Access Memory—Addressable memory with read-in and read-out capability.

Dependency Notation

mAm	Address Dependency—Binary affecting inputs of affected outputs. The m prefix is replaced with a number that differentiates between several address inputs, indicates dependency, or indicates demultiplexing and multiplexing of address inputs and outputs. The m suffix indicates the number of cells that can be addressed.
Gm	Gate (AND) Dependency—Binary affecting input with an AND relationship to those inputs or outputs labeled with the same identifier. The m is replaced with a number or letter (the identifier).
Cm	Control Dependency—Binary affecting input used where more than a simple AND relationship exists between the C input and the affected inputs and outputs (used only with D-type flip-flops).
Vm	OR Dependency—Binary affecting input with an OR relationship to those inputs or outputs labeled with the same identifier. The m is replaced with a number or the letter (the identifier).
Fm	Free Dependency—Binary affecting input acting as a connect switch when active and a disconnect when inactive. Used to control the 3-state behavior of a 3-state device.

NOTE

The identifier (m) is omitted if it is one—that is, when there is only one dependency relationship of that kind in a particular device. When this is done, the dependency indicator itself (G, C, F, or V) is used to prefix or suffix the affected (dependent) input or output.

Table 8-2. Schematic Diagram Notes (8 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Miscellaneous

Schmitt Trigger—Input characterized by hysterisis; one threshold for positive going signals and a second threshold for negative going signals.

Active

Active State—A binary physical or logical state that corresponds to the true state of an input, an output, or a function. The opposite of the inactive state.

Enable

Enabled Condition—A logical state that occurs when dependency conditions are satisfied. Although not explicitly stated in the definitions listed above, functions are assumed to be enabled when their behavior is described. A convenient way to think of it is as follows:

A function becomes active when:

- it is enabled (dependency conditions—if any—are satisfied)
- and its external stimuls (e.g., voltage level) enters the active state.

SERVICE SHEET BD1
OVERALL BLOCK DIAGRAM

PRINCIPLES OF OPERATION

General

The Power Meter is a microprocessor controlled dual channel power meter with a built in 1 mW 50 MHz power reference. Figure 8-1 shows a simplified overall diagram of the Power Meter. For purposes of explanation and troubleshooting the Power Meter is divided into the following three functional sections:

1. The Controller Section.
2. The Amplifier Section.
3. The Power Supply Section.

The Controller Section enables the functions that the user requests by pressing front panel keys (local operation) or by HP-IB program codes (remote operation). The overall power range and frequency response of the Power Meter is determined by the power sensors that are connected to channel A and channel B.

Under microprocessor control, the analog power inputs from the power sensors are measured and digitized by the Amplifier Section. The Controller Section calculates and displays the measurement result in the requested units.

The following discussion explains Figure 8-9 Overall Block Diagram shown on the foldout.

Controller Section

The microprocessor based Controller Section consists of the following assemblies:

1. A1 Keyboard Assembly.
2. A2 Display Assembly.
3. A3 Central Processing Unit (CPU).
4. A11 HP-IB Assembly.

The CPU provides the timing, calculation, and control for the instrument. The microprocessor executes instructions stored in the read only memory (ROM). Data is exchanged between the microprocessor and the other blocks of the CPU over the data bus (D0-D7). The elements of the CPU are enabled to respond to the data on the data bus by control signals. These signals are derived

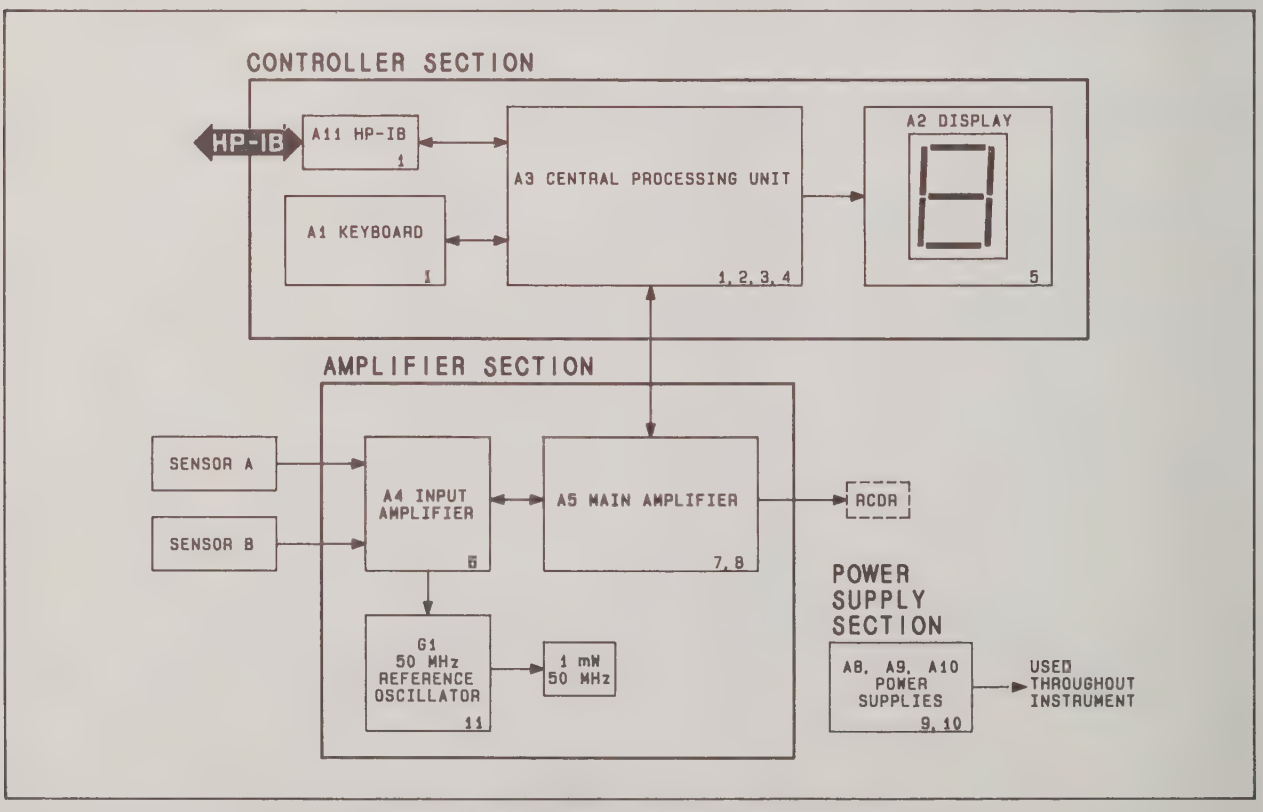


Figure 8-1. Power Meter Simplified Overall Diagram

SERVICE SHEET BD1 (cont'd)

from the address bus (A0-A15) by the address and control decoders. Data values that must be stored are placed in the random access memory (RAM).

The CPU sends and receives data to and from other assemblies through the keyboard interface, HP-IB interface, and the analog input/output (I/O) interface. It also sends data to the display through the display interface. The display indicates the current status of the Power Meter. This status information can consist of the current measurement configuration and results, or one of the error messages contained in Table 3-8.

A simplified flowchart of the interrupt control routine for the Power Meter is shown in Figure 8-2. Note that there are no asynchronous interrupts. The key to understanding the operation of the firmware is to understand that in resides in ROM and is interrupted at 1 ms intervals by a hardware generated interrupt. During these 1 ms intervals

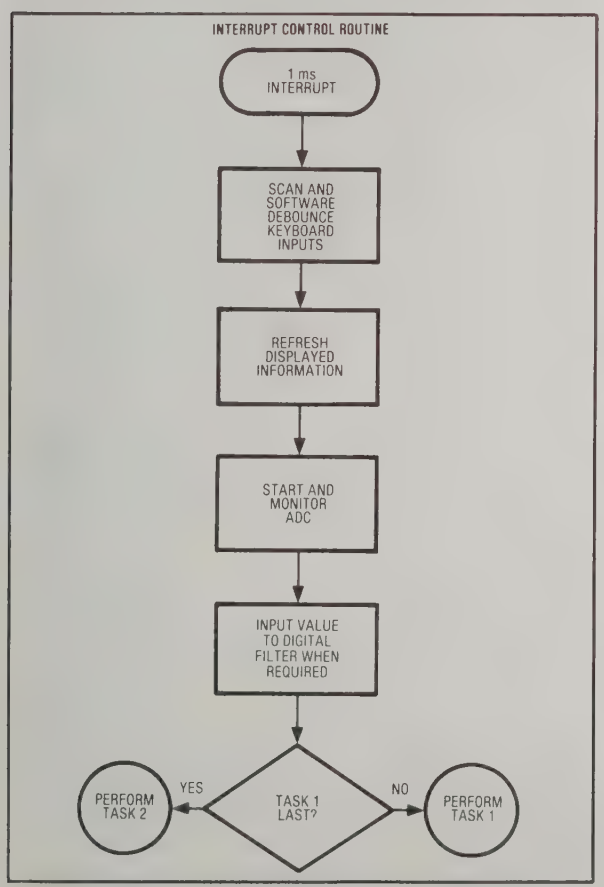


Figure 8-2. Interrupt Control Routine Flowchart

the firmware accomplishes the required configuration changes, calculations, and updates to perform all of the Power Meter's defined functions.

The firmware has the following three main routines:

1. The interrupt routine provides synchronous control of all Power Meter functions.
2. The task 1 routine primarily handles user commands (both front panel and HP-IB). A flowchart of the Task 1 routine is shown in Figure 8-3.
3. The task 2 routine primarily handles the mathematical calculations for the required measurement results and sets error flags when required. A flowchart of the Task 2 routine is shown in Figure 8-4.

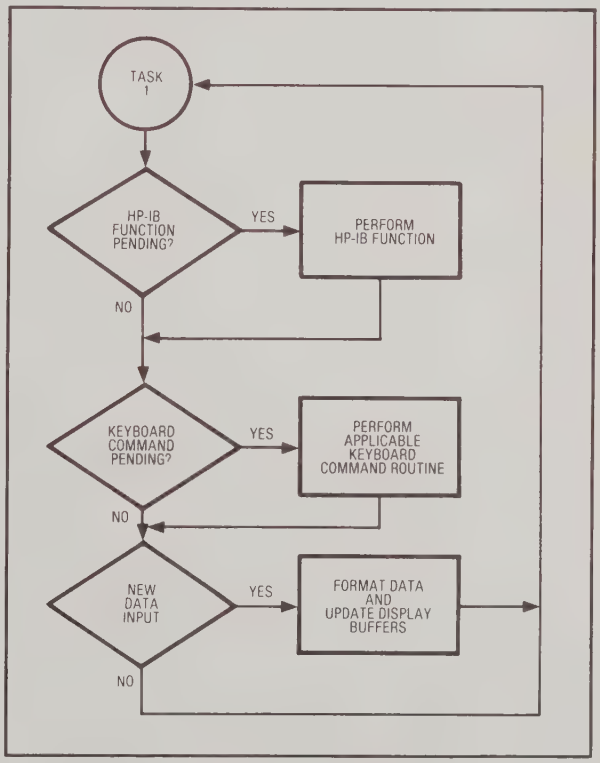


Figure 8-3. Task 1 Flowchart

When the instrument powers up, the status byte is set to 0 and a GT2 (trigger with delay response to group execute trigger) command is executed (refer to Section III for an explanation of the status byte). After power up, hardware generated interrupts occur every 1 ms. Each interrupt causes the interrupt routine to perform the following functions:

SERVICE SHEET BD1 (cont'd)

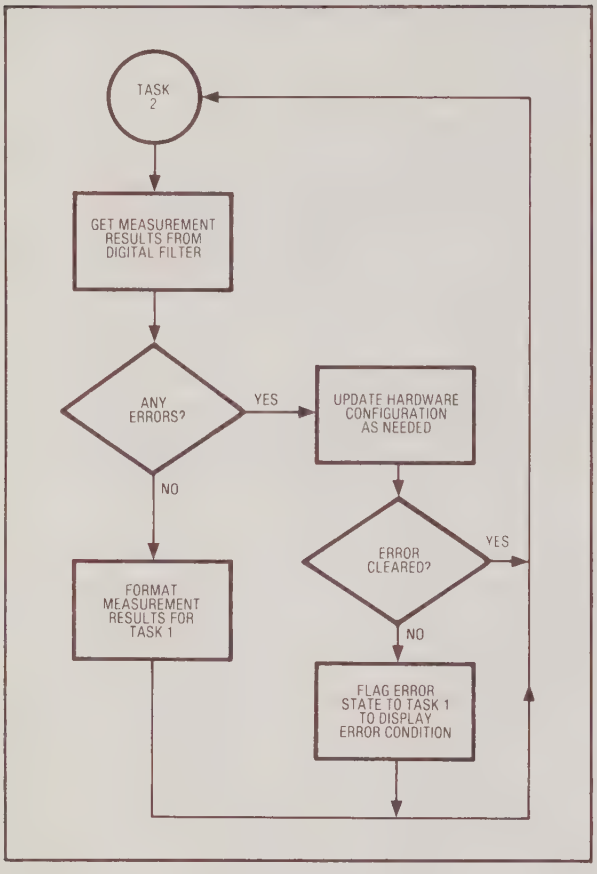


Figure 8-4. Task 2 Flowchart

1. Scan the keyboard inputs to determine if a key has been pressed. This subroutine also debounces the keyboard input by verifying that after approximately 10 ms the same key pressed indication is still present.

2. Refresh the front panel display information. This sequence does not change any information, it only allows the display to be refreshed at a rate that provides flicker free operation.

3. Start and monitor the analog to digital conversion (ADC). Once the ADC is started its operation is independent of the software.

4. Input the power measurement value to the digital filter when required. The digital filter is updated every 50 ms (every 50 interrupts). This update rate is maintained regardless of the state of the instrument, HP-IB activity, or front panel activity.

When the interrupt routine is finished, it returns to either task 1 or 2. The software logic requires that the returns alternate between task 1 and task 2 and that it pass control to the task that was not interrupted. This allows both tasks to have an equal amount of execution time independent of what each is working on. This method of sharing execution time ensures that a high level of HP-IB activity does not slow down mathematical calculations nor does mathematical activity slow down the HP-IB response time.

When task 1 is executing, it performs the following functions:

1. Determine if any HP-IB function is pending and, if it is, perform it. These functions can consist of sending or receiving data over HP-IB or executing HP-IB commands.

2. Determine if any keyboard command is pending and, if it is, perform it. All key functions have individual routines that are performed each time the key is pressed.

3. Determine if there is new data available. This data can be an updated measurement result, new Power Meter configuration or an error message. If there is new data, the display data buffers are updated and the new information is displayed when the display is refreshed during the interrupt routine.

When task 2 is executing, it performs the following functions:

1. Gets the last measurement result from the software digital filter. This output is the average output of the digital filter at that time. A detailed explanation of the digital filter is contained in Service Sheet BD3.

2. Checks to determine if any error conditions exist. Some error conditions can be cleared by updating the hardware configuration. For example, the Power Meter can autorange to a different range as required. If the error is cleared, task 2 loops back and begins again. If the error can not be cleared, an error flag is set and the appropriate error message is passed to task 1.

3. If no error condition exists, the measurement result is formatted and passed to task 1.

SERVICE SHEET BD1 (cont'd)

Note that either task 1 or 2 continues to run until the next 1 ms interrupt. The interrupt routine is then executed and the sequence repeated for the other task.

When the Power Meter is in local operation the keyboard can be used to select the required measurement configuration. The instrument remembers the last measurement configuration entered prior to turning off power and returns to that configuration when power is turned on. The last mesurement configuration that is saved in RAM is battery protected by disabling the write to RAM capability.

When the Power Meter is in remote operation, with local lockout set, all front panel keys except the LINE ON/OFF are disabled. The measurement configuration is selected by programmed inputs applied through the HP-IB. Remote operation can only be enabled via HP-IB.

Amplifier Section ⟨√3⟩

The Amplifier Section consists of the following assemblies:

1. A4 Input Amplifier.
2. A5 Main Amplifier.
3. G1 50 MHz Reference Oscillator.

In addition, Option 002 adds two rear panel sensor input ports in parallel with front panel inputs and a second 50 MHz Reference Oscillator (G2) with its output on the rear panel.

All of the operating functions of the Amplifier Section are enabled and sequenced by the control signals from the CPU. As required, the correct sensor input is applied through channel A or B of the A4 Input Amplifier Assembly to the A5 Main Amplifier Assembly. The primary function of the main amplifier is to selectively attenuate, amplify, filter, and digitize the input signal under the direction of the CPU. This allows the CPU to obtain the neccessary data to compute and display the measurement results.

In addition to the primary signal flow, other signals, such as the power sensor resistor signal, can be applied through the multiplexer and digitized. The CPU uses the results of these measurements to determine if any changes or corrections are required.

The 50 MHz Reference Oscillator (G1) is enabled by the CPU when either the OSC or entry mode CAL ADJ (calibration) key is pressed. The oscillator is turned off manually if the OSC key is pressed again or automatically at the end of the calibration cycle. If the optional rear panel reference oscillator is installed, both oscillators are turned on and off at the same time. Each oscillator provides an independent 1 mW 50 MHz output that can be used for calibration or as a signal source when troubleshooting.

Power Supply Section ⟨√1⟩

The following five power supplies are isolated to reduce the unwanted interaction in the Power Meter:

1. The +5V digital power supply.
2. The pulsed +5V display power supply. This power supply is enabled by the CPU timer circuit.
3. The +15V analog power supply.
4. The −15V analog power supply.
5. The +10.4V power supply for the fan.

Because of the high precision requirements, the Power Meter uses separate grounding points for each type of digital and analog signal. Grounding is very important. B-GND is the chassis or earth ground point that is connected to the protective earth terminal of the power receptacle. B-GND is defined as a point at the rear panel RCDR BNC connector. See Figure 8-5 for a simplified diagram of the distribution of the grounds used on the different boards. The grounds are defined as follows:

1. The main instrument ground at the RCDR BNC connector.
2. The A-GND is defined as the ground at the sensor bulkhead that is supplied to the input being measured. The A-GND is not a true ground, but a reference for the signal being amplified through the bandpass amplifiers. The A-GND is created on the A5 Main Amplifier Assembly and applied to the A4 Input Amplifier Assembly. A detailed explanation of the creation of the A-GND is provided on Service Sheet 8.
3. The B-GND is the low current analog ground. It is applied directly to the main amplifier from the main instrument ground. It is used on the main amplifier filters and the analog to digital conversion (ADC).

SERVICE SHEET BD1 (cont'd)

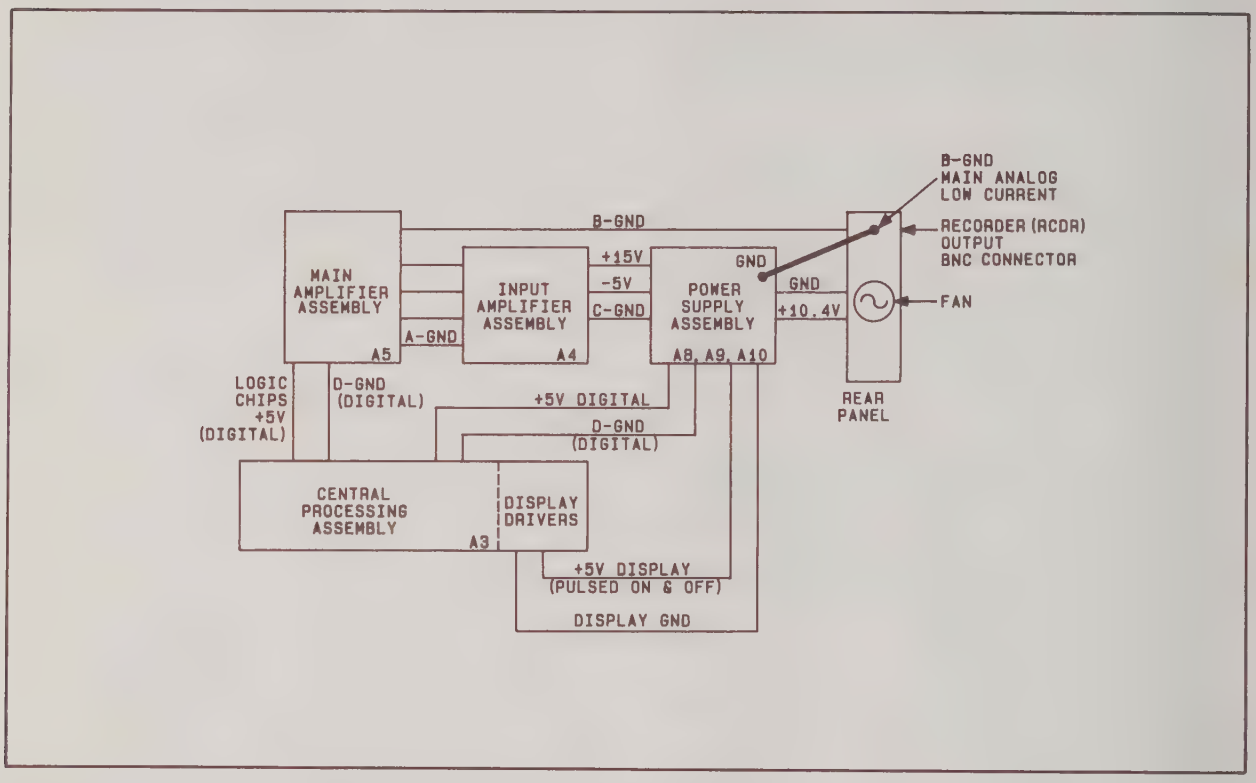


Figure 8-5. Simplified Power Supply Grounding

4. The C-GND is the high current main analog ground. The C-GND is tied to the main instrument ground on the A9 Regulator Assembly and is used on the input amplifier and main amplifier assemblies.

5. The D-GND is the main digital ground. The D-GND is tied to the main instrument ground on the A10 Interconnect Assembly and is applied to the A3 Central Processing Unit Assembly (CPU). From the CPU it is applied to the main amplifier.

6. The display ground is the ground for the display drivers. The display ground is tied to the main instrument ground on the A10 Interconnect Assembly. It is applied to the CPU display driver circuits and used only by the +5V pulsed power supply.

TROUBLESHOOTING HINTS

To begin this troubleshooting it is assumed that Section II Installation, Line Voltage and Fuse Selection checks are completed.

The troubleshooting checks on this service sheet are used to isolate a malfunction to one of the three major sections; Controller Section, Amplifier Section, or Power Supply Section. A symbol with a check mark and a number is used to show the order of the checks. This symbol is shown on the block diagram to locate the section that the troubleshooting relates to. The checks start with the Power Supply Section, move on to the Controller Section and then to the Amplifier Section. The checks are easy to perform and provide key information. In most instances the checks isolate a failure to a major assembly. The comments associated with each procedure summarize the known information as a result of passing or failing the check.

Test Equipment

Oscilloscope	HP 1740A
Power Sensor (1 or 2)	HP 8480 series
Sensor Cable	HP 11730A
Range Calibrator	HP 11683A
Digital Voltmeter(DVM)	HP 3456A

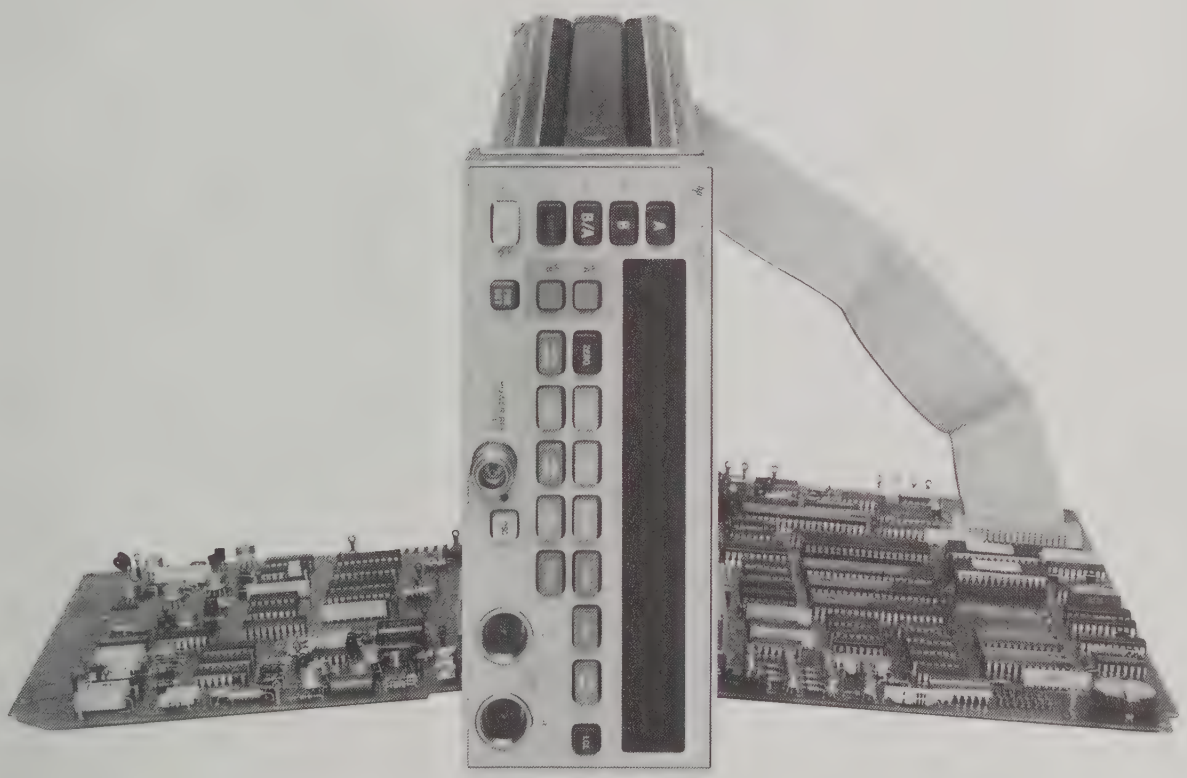


Figure 8-6. Power Meter Service Position

SERVICE SHEET BD1 (cont'd)

Power Supply Section √1

To perform the line check remove the Power Meters' top and bottom covers. Unscrew the three captive screws holding the A3 CPU Assembly and the two captive screws holding the A5 Main Amplifier Assembly. Swing out the hinged printed circuit boards to the service position. See Figure 8-6 showing this position. After the covers are removed and the assemblies are in the service position connect the line power cable. Press the LINE key to the ON position. The normal indications are:

1. The fan runs indicating line voltage or Mains (ac) power is present at the transformer, that it is being rectified, and regulated giving the voltage necessary for the motor control module to drive the dc fan.

2. The four red LEDs (light emitting diodes) on the A9 Regulator Assembly are lighted indicating that the regulated supplies are operating. This does not mean that the supplies are within the required tolerances.

Abnormal Indications. If an abnormal indication occurs:

1. Check rear panel line fuse.

2. Measure the individual regulated supplies. Test points and levels are shown on this block diagram. The +15 Vdc and −15 Vdc supplies should be equal but of opposite polarity and within 0.05 Vdc of each other. Measure +15 Vdc (14.25 Vdc to 15.75 Vdc) at A9TP8. Measure the -15 Vdc at A9TP7 and adjust it if necessary to match the +15 Vdc supply. Measure the +5 Vdc at A9TP4 and adjust it if necessary to 5.00 ± 0.05 Vdc. If the supplies are found to be in error and cannot be adjusted refer to Service Sheets 9 and 10 for more details.

Controller Section √2

If the Turn-on and Operator's Checks were completed in Section III the Controller Section √2 can be skipped. In that case proceed to Amplifier Check √3.

Procedure. To verify the controller power up routine press the LINE key to cycle from the power OFF to power ON condition. This will initiate a diagnostic routine stored in ROM. This routine is a check of ROM, RAM, and the displays. Observe the front panel seven segment displays and annunciators. The normal indications are:

1. All front panel indicators are lighted to provide a visual inspection of each front panel display segment and annunciator.

2. All the display segments (large and small) will display the number eight. The center three columns and the two right-hand columns of annunciators will be lighted.

3. When the power up routine is completed and after a short flash of all dashes the display will show some message defining the next step to be taken. This message will be self explanatory.

Abnormal Indication. If an abnormal indication occurs:

1. If all displays fail to light, check the +5V display enable CLK (clock) at A9TP1 with the oscilloscope. The waveform should be as shown in Figure 8-7.

2. When only one of the display segments or annunciators fails to light, check respective components and display drive circuits. Refer to Controller Section Troubleshooting BD2.

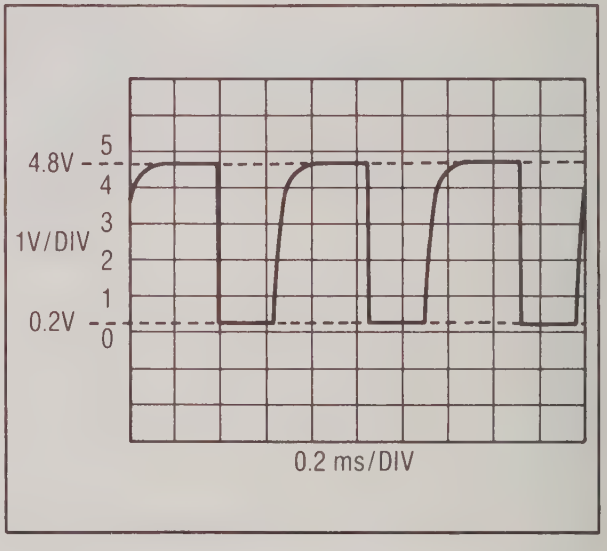


Figure 8-7. Display Enable Waveform

Amplifier Section √3

As a check of the Amplifier Section, two approches can be taken depending on the test equipment avail-

SERVICE SHEET BD1 (cont'd)

able. If only a power sensor is available it can be used with the 1 mW POWER REF to set up some known conditions for troubleshooting. If the HP 11683A Range Calibrator is available it can used as a variable source for checking the ranges.

Procedure one. Connect a power sensor to channel A and to the POWER REF (1.00 mW 50 MHz). Press PRESET. Press ZERO and wait for routine to finish. Press CAL ADJ and enter ref cal factor, wait for routine to finish. Press the POWER REF OSC (oscillator) key to turn on the 50 MHz signal. Press CAL FACTOR and enter ref cal factor value. The normal indication is:

1. The display should indicate as shown in Table 8-3 and channel A.

Table 8-3. Power Displayed for 1 mW Power Reference

Power Sensor	Displayed Power
HP 8481B (attenuator disconnected)	1.000 Watt
HP 8482B (attenuator disconnected)	1.000 Watt
HP 8481H	100.0 -3 Watt (mW)
HP 8482H	100.0 -3 Watt (mW)
HP 8485A	1.000 -3 Watt (mW)
HP 8481A	1.000 -3 Watt (mW)
HP 8482A	1.000 -3 Watt (mW)
HP 8483A 75Ω	1.000 -3 Watt (mW)
HP 8484A with HP 11708A 50 MHz Reference Attenuator)	1.000 -6 Watt (micro/W)

Abnormal Indication. If an abnormal indication occurs:

1. An error message indicating a faulty sensor. Try a second sensor.
2. Display shows no REF (no power reference). Check the plus and minus 15 Vdc power supplies, connected to the reference oscillator. Refer to A4 Input Amplifier Assembly on Service Sheet 6.
3. The COMP OUT (comparator out) or RAMP END signal at test point A5TP4 is not as shown in Figure 8-8. Refer to Amplifier Section Troubleshooting BD3.
4. The RCDR (rear panel recorder) BNC output is not 1 Vdc. Refer to troubleshooting BD3.

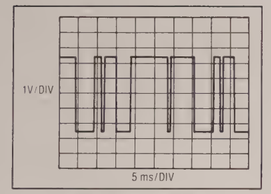


Figure 8-8. Ramp End Waveform

Procedure two. Connect the range calibrator to the Power Meter using the HP 11730A power sensor cable. Set up the controls to use the range calibrator as a controlled source.

FUNCTION ..... STANDBY
POLARITY ..... NORMAL
RANGE ..... 1 mW
LINE ..... ON

1. Set the Power Meter control.
   Press ..... ZERO

The normal indications are:

2. The display should indicate 0.00 ± -6 WATT (micro/W)
3. Change the range calibrator control setting.
   FUNCTION ..... CALIBRATE
4. Set the Power Meter controls.
   Press CAL ADJ, -(SET B), 100, and ENTER. (The minus sign is needed when an external power reference source is used.)

The display should indicate 1.000 -3 WATT (mW) and follow the range calibrator as the range is changed.

Abnormal Indication. If an abnormal indication occurs.

1. Channel A or channel B problems can be narrowed down by connecting the power sensor to the opposite channel and observing the results.
2. The connecting cable from the front panel A or B connector to channel A or B on the amplifier can also be switched at the point where it connects to the A4 Input Amplifier Assembly. This indicates a problem with a cable or with the input amplifier analog circuitry. Refer to troubleshooting BD3.

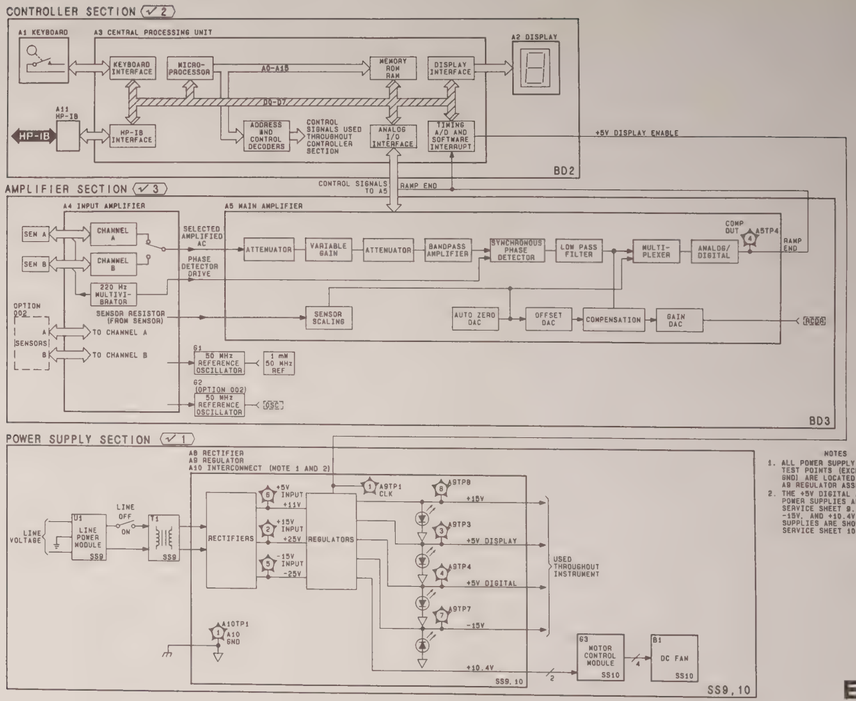


Figure 8-9. Overall Block Diagram

SERVICE SHEET BD2
CONTROLLER SECTION

PRINCIPLES OF OPERATION

General

As shown on the block diagram, the A3 Central Processing Unit (CPU) is the major physical component of the controller. The controller can be divided into the following five functional sections:

1. The data input/output circuits (Service Sheet 1). These circuits consist of the A1 Keyboard Assembly, the A11 HP-IB Interface Assembly, and part of the A3 CPU Assembly.
2. The microprocessor and memory circuits (Service Sheet 2). These circuits are all contained on the A3 CPU.
3. The timer and peripheral interface adapter (PIA) circuits (Service Sheet 3). These circuits are all contained on the A3 CPU.
4. The display drivers (Service Sheet 4). These circuits are all contained on the A3 CPU.
5. The front panel display circuits (Service Sheet 5). These circuits are all contained in the A2 Display Assembly.

The CPU controls the rest of the instrument by using the following three buses to enable, address, and transfer data to the other sections of the instrument:

1. The control bus is derived from part of the address bus and hardware generated signals such as power fail or free run. These signals are used to enable specific digital circuits when they are required to perform their designated functions.
2. The address bus controls access to the ROM and RAM. It also supplies inputs to the control decode circuits.
3. The data bus transfers information throughout the controller. Note that the data bus is buffered at the data inputs to the microprocessor, at the ROM and RAM outputs, at the HP-IB circuits and at the I/O interface. These buffers provide the required signal strength to drive the associated circuits. They also help to isolate problems and aid in locating a malfunction when one occurs.

Data Input/Output Section

The A1 Keyboard Assembly is used during local operation to select the measurement configuration of the Power Meter. When a key is pressed, the keyboard priority encoder in the CPU encodes and stores this information in the cathode data display and keyboard scan PIA (Peripheral Interface Adapter). When the PIA is enabled, this information is transferred to the microprocessor and the appropriate changes to the instrument are initiated.

The A11 HP-IB Assembly is used during remote operation to interface the HP-IB to the HP-IB interface management and transceiver circuits on the CPU. These circuits manage the exchange of the bi-directional information between the CPU and the HP-IB.

The HP-IB assembly also contains the manual HP-IB address switch. The output from this switch is applied to the HP-IB address buffer on the CPU. Note that the preset HP-IB address that is selected on the switch is only read by the CPU if the current HP-IB address set from the front panel and stored in RAM is lost.

Microprocessor and Memory Circuits

The microprocessor and memory circuits with their associated busses form the kernel of the CPU. The microprocessor reads the permanently stored programs in the ROM and uses these instructions to control the operation of the Power Meter. During troubleshooting this kernel can be isolated and exercised by grounding A3TP4 FREE RUN prior to applying power. The clock and timer interrupt circuits provide the synchronization required for correct operation of the CPU.

The address and control decode circuits derive the digital control signals from part of the address bus and hardware monitoring inputs. This process is described in detail on Service Sheet 2. These control signals are used to enable different digital circuits when required by the microprocessor.

The RAM is used for temporary data storage while the Power Meter is operating. However, combined with the reset power fail, RAM chip enable, and the battery circuits, part of the RAM is used to store data when the Power Meter is turned off. The following information is retained when power is turned off:

1. The current front panel setup.
2. Any other front panel setup that has been saved using the STORE key, or the HP-IB program code ST.
3. The current zeroing and calibration data. Additional information on the zeroing and calibration software routines is contained in Service Sheet 3.

When power is applied to the instrument it goes through its pretest routine and the reset power fail resets the CPU to a predetermined hardware configuration. The CPU then retrieves the last front panel setup stored in RAM and establishes the required measurement configuration. This controlled restart ensures that the Power Meter always starts operation from a known configuration.

When power is turned off (or lost), the combined action of the reset power fail and RAM chip enable circuits protect the data stored in the RAM. This is accomplished by immediately disabling the input /output functions of the RAM and applying the battery voltage to the Vcc input of the portion of RAM used for data storage when power is off. The input/output functions are disabled to prevent any false data from being stored while the power level is dropping. The required restart data is always present in RAM.

The service function switch and buffer can select and initiate diagnostic programs that are used when troubleshooting the Power

Meter. A list of the available diagnostic programs and instructions on how to run them are contained in the troubleshooting section of this service sheet.

Timer A/D, PIA, and Latch Circuits

The two main purposes of the timer A/D or ADC (analog to digital converter) circuit are to time the A/D conversion in the A5 Main Amplifier Assembly and supply the 1 ms software interrupt to the timer interrupt latch. The 4 MHz input clocks the timer A/D circuit. The start ramp signal starts the internal counter at the same time as the ramp generator in the main amplifier is started. When the measured input signal and the ramp generator output are equal, the ramp end signal from the main amplifier stops the counter. The counter output is read to the microprocessor under software control. The microprocessor uses this data to perform the required computations and displays the results on the front panel A2 Display Assembly.

The analog I/O PIA (input/output peripheral interface adapter) applies the required measurement configuration control signals to the main amplifier.

The cathode data display and keyboard scan PIA controls the addressable data display latch circuit and the inputs and outputs to the A1 Keyboard Assembly. The addressable data display latch circuit controls the cathode data display drivers.

The LED data latch is enabled by the anode data display and LED address decode circuit and controlled directly by the microprocessor. The LED lighting patterns are used to obtain circuit information when troubleshooing the instrument. Additional information on how to use the LED information is contained in the troubleshooting section of this service sheet.

The anode data display and LED address decode circuit also selectively enables one of the anode data display latches.

Display Drivers

The anode and cathode display drivers are used to refresh the front panel display. The sequence of the drivers is controlled by the CPU through the anode data display latches and addressable data display latch and drivers (Service Sheet 3).

Display Assembly

The A2 Display Assembly displays the current instrument configuration and the appropriate measurement result or error message.

TROUBLESHOOTING HINTS

The troubleshooting checks on this service sheet are used to narrow down a malfunction to one of the following assemblies; A1 Keyboard Assembly, A11 HP-IB Assembly, A3 Central Processing Unit

(CPU) Assembly, or the A2 Display Assembly. The A3 CPU is the major block. Its schematic diagrams are on Service Sheets one through four (SS1, SS2, SS3, SS4) as shown in the lower right-hand corner of the solid line boxes.

The checks will cover changing switch positions of the service function switch (A3S1) on the A3 CPU, exercising the front panel keys, monitoring the front panel displays, and checking some signatures. When these checks pass, it can be assumed that a major portion of the circuitry is functioning.

Test Equipment

Signature Multimeter ..... HP 5005B

Service Function Switch

The service function switch A3S1 contains four single pole double throw toggle switches that are provided to control data bus bits (D0 through D7) going to the microprocessor. With the Power Meter in the service position these switches can be set to several postions corresponding to some diagnostic routines. The routines can either be for manual or automatic tests of the digital circuitry.

A3S1 can be loaded on the printed circuit board in either of the two positions shown in Figure 8-10.

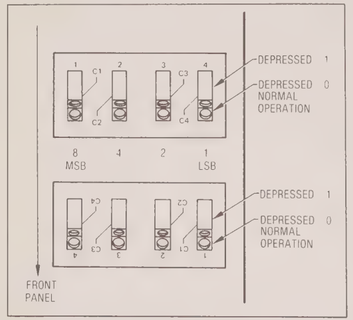


Figure 8-10. Service Function Switch

Table 8-4. Test Switch Pattern

MSB 8	4	2	LSB 1	Decimal Equivalent	Tests
0	0	0	0	0	Normal Operation
0	0	0	1	1	Extended Test Mode
1	0	1	0	10	Manual Display Check
1	0	1	1	11	Automatic Display Check
1	1	0	0	12	Keyboard Manual Check
1	1	0	1	13	Memory Check (RAM)
1	1	1	0	14	Signature Analysis
1	1	1	1	15	A to D Adjustment

Service Function Switch Checks

In normal operation with the switch in the all zeros, or normal operating position, the power up routine can be executed. This diagnostic performs a check of ROM, RAM, and displays as was mentioned earlier. However, by changing the least significant bit (LSB) from a zero to a one on the switch an extended test mode can be accessed.

EXTENDED TEST MODE CHECK

Set the switch to decimal one or the least significant bit to a one. This enables an extended test mode for the calibration and zeroing errors reporting routine. This position also allows for HP-IB control of the DACS (digital to analog converters) as well as a check of the variable gain amplifier. The checking of the DACS and the variable gain amplifier will be performed at the service sheet level of troubleshooting. The normal indication is:

1. The display will show no CH A if a power sensor is not connected and PLEASE 0 if a power sensor is connected but has not been zeroed.

Abnormal Indication

1. If a problem is detected in the extended test mode an error number will be displayed. The explanation of these errors and their relationship to the zeroing and calibration routines will be given on Service Sheet 1.

Overall Block Diagram SERVICE SHEET BD1

MANUAL DISPLAY CHECK

Set switch to decimal ten. This will enable a manual test of the front panel displays. Repeated pressing of the "A" key will light each LED segment and annuciators. The normal indication is:

1. All segments of the large LED's, all of the smaller number eights, and all of the annunciators will light, one at a time as the "A" key is pressed. Continue to press until the sequence starts to repeat.

Abnormal Indication

1. If any of the displays fail to light refer to Service Sheets 4 and 5.

AUTOMATIC DISPLAY CHECK

Set switch to decimal 11. This check is similar to the manual display check except the displays are lighted and sequenced through automatically. The normal indication is:

1. At turn on all displays will be lit. This will be followed by a walking through turn on of each LED segment large and small. Then the annunciators will be turned on in two groups.

Abnormal Indication

1. If any of the displays fail to light refer to Service Sheets 1, 3, 4, and 5.

KEYBOARD MANUAL CHECK

Set the switch to decimal 12.

Each front panel key can be pressed and a corresponding number will be displayed (01 through 21) starting with key "A". Refer to the following list:

A=01
B=02
B A=03
SHIFT=04
SET A=05
SET B=06
PRE SET=07
ZERO=08
AUTO RANGE=09
CAL ADJ=10
MNL RANGE=11
CAL FACTOR=12
AUTO FILTER=13
OFFSET=14
MNL FILTER=15
OSC=16
STORE=17
RECALL=18
REL=19
dBm WATT=20
LCL=21

The normal indication is:

1. The display shows 00 at turn on. This increments to 01 when the "A" key is pressed and so on through the keyboard as each key is pressed up to 21 for the "LCL" key.

Abnormal Indication

1. When a key is pressed and the number doesn't change to the number corresponding to that key then either the key or associated circuitry could be the problem. Refer to Service Sheets 1, 3, 4, and 5.

MEMORY (RAM) CHECK

Set the switch to decimal 13.

The front panel display is blank during this check. To verify the check is being run observe the anode data bus bits AD0 through AD7 LED's on the A3 CPU Assembly near A3S1. At the next power up there will be a momentary rcl (recall) Fail error message since information in memory was written over during this test routine. The normal indications are:

1. The data bus bit pattern changes as shown in Table 8-5.

Table 8-5. Data Bus Test Pattern

	Bits	Bit Pattern							
		Start	Test One Start	Test One	Test One Complete	Test Two Complete Error	Test Two Complete	Restart	
RAM 1 A3U12	D0	0	1	0	1	0	0	1	
	D1	0	1	0	1	0	0	0	1
RAM 2 A3U13	D2	0	0	1	0	1	1	0	
	D3	0	0	1	0	1	1	0	
How many times the test was executed and passed	D4	0	0	0	1	0	1	0	
	D5	0	0	0	0	1	1	0	
	D6	0	0	0	0	0	1	0	
	D7	0	0	0	0	0	1	0	

SERVICE SHEET BD2 (cont'd)

Abnormal Indications

1. If a RAM failure occurs the test will flash LED's for bits D0,D1 indicating a problem with A3U12, or flash LED's for bits D2,D3 when A3U13 has a problem.

SIGNATURE ANALYSIS CHECK

Set the switch to decimal 14.

This is a check that uses programmed signatures as a method of trubleshooting. Correct signatures at the peripheral interface adapter (PIA) for the analog input/output give a high confidence factor that a major portion of the digital circuitry is working.

Signature Multimeter Control Settings

FUNCTION ..... SIGNATURE NORM
THRESHOLD ..... TTL
POLARITY ..... CLOCK
START
STOP

Signature Multimeter Pod Connections

Connect: START/ST/SP green to A3TP9 STRT 2
STOP 2

STOP/QUAL red to A3TP9 STRT 2
STOP 2

CLOCK yellow to A3TP6 CLK SA

black to A3TP7 GND

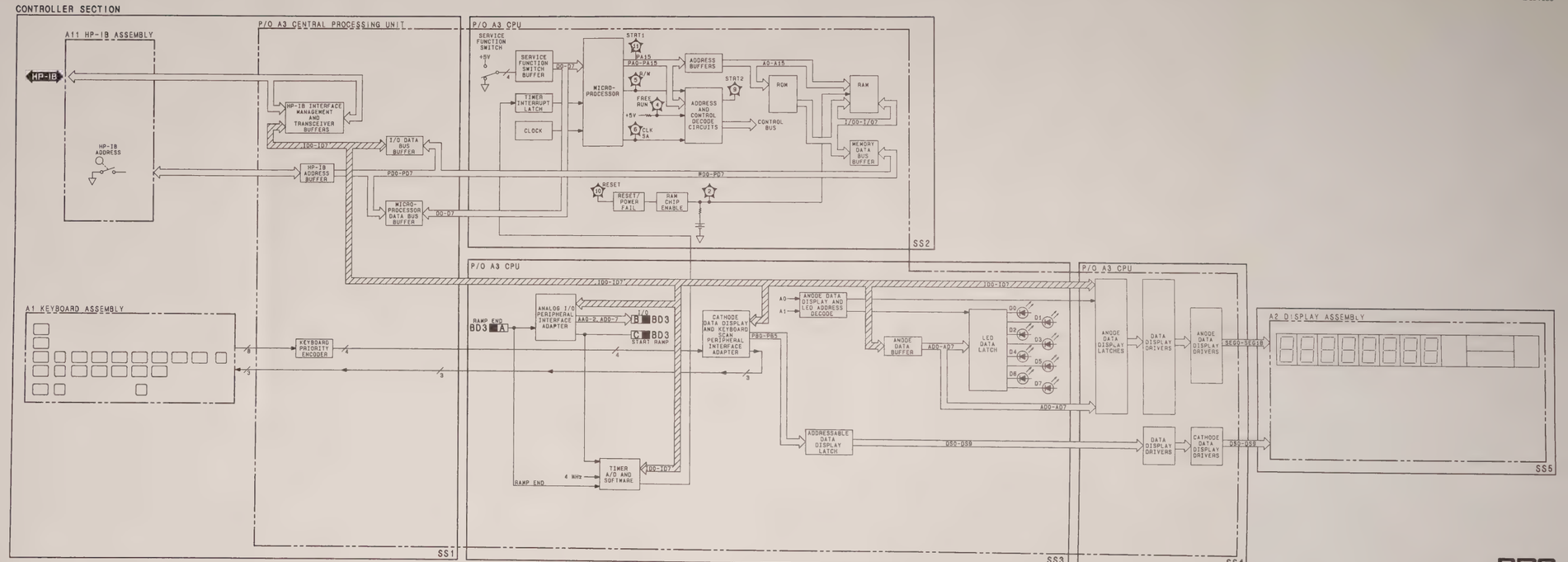
The normal indication is to have valid signatures at the analog I/O (input/output) peripheral interface adapter A3U21.

1. Valid signatures at A3U21 the analog I/O (input/output) peripheral interface adapter.

Pin Number	Signature	Pin Number	Signature
1	0000	21	5C18
2	F08A	22	CUFC
3	34PA	23	3U39
4	F942	24	CUFC
5	0000	25	CUFC
6	0000	26	P5A4
7	0000	27	A878
8	0000	28	P5CC
9	CUFC	29	8P88
10	1526	30	6377
11	43C5	31	U6P7
12	70U1	32	48A6
13	A47F	33	AHA7
14	848A	34	CUFC
15	5UHU	35	450C
16	45A2	36	569A
17	8F07	37	CUFC
18	CUFC	38	CUFC
19	CC70	39	CUFC
20	CUFC	40	0000

Abnormal Indication

1. If any of the signatures are different from those given, troubleshoot the bad signal line by referring to Service Sheet 3.



BD2

Figure 8-11. Controller Section Block Diagram

SERVICE SHEET BD3
AMPLIFIER SECTION

PRINCIPLES OF OPERATION

General

As shown on the block diagram the A4 Input Amplifier Assembly and the A5 Main Amplifier Assembly are the major physical components. The Amplifier Section can be divided into the following five functional sections:

1. The connected power sensor (Not shown on the block diagram refer to the Power Sensor Operating and Service Manual).
2. The input amplifier circuits (Service Sheet 6). These circuits are on the A4 Input Amplifier Assembly.
3. The digital I/O and DAC circuits (Service Sheet 7). These circuits are all contained on the A5 Main Amplifier Assembly.
4. The amplifier, detector, and comparator circuits (Service Sheet 8). These circuits are all contained on the A5 Main Amplifier Assembly.
5. The 1 mW 50 MHz Power Reference circuits (Service Sheet 11)

Connected Power Sensor and Input Amplifier Circuits

The connected power sensors determine the frequency range, dynamic range, and measurement accuracy of the combined power sensor and Power Meter. A simplified block diagram of the interconnection between the power sensors, the two channels of the input amplifier, and the monitoring circuits in the main amplifier is shown in Figure 8-12. The basic operation of these circuits is described in the following paragraphs.

The power sensor dissipates the RF input power into a 50 or 75 Ohm impedance and generates a dc voltage proportional to the RF input power level.

The 220 Hz multivibrator provides the 220 Hz drive signals to the power sensors which are modulated by the dc voltage. The resulting sensor output is a 220 Hz signal that is proportional in amplitude to the RF input power level and is in phase with the 220 Hz reference signal that is applied to the synchronous phase detector in the Power Meter's main amplifier.

The shaping feedback circuit serves to reduce the gain of the input amplifier at higher power levels. This reduction in gain is required to offset the improved efficiency of the power sensing elements at the higher power levels.

The sensor resistor input to the sensor resistor circuit in the main amplifier is used by the controller to determine which model power sensor is connected to an input channel. Note that any two HP 848X power sensors can be connected to the Power Meter. The controller is able to adjust the individual channel input to the connected power sensor and provide the correct measurement result for each channel. If the Option 002 rear panel input ports are present, the controller can determine if more than one power sensor is connected to the same channel input. For example, if power sensors are connected to both the front panel and rear panel A inputs, error message 33 "2 inPutS" is displayed.

The output from the auto zero DAC on the main amplifier is set by the controller and in conjunction with stored values in the software is used to remove any dc offset voltage associated with the individual power sensors.

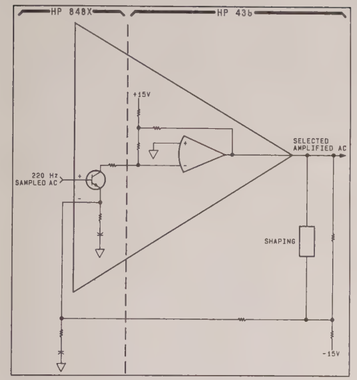


Figure 8-12. Simplified Power Sensor and Input Amplifier Diagram

The controller sets the miscellaneous buffer on the main amplifier to connect the following signal paths for the selected input channel:

1. The amplified ac output.
2. The sensor resistor input.
3. The sensor ground reference to the A-GND circuit on the main amplifier.

The power sensor and A4 Input Amplifier Assembly function together to amplify the modulated 220 Hz signal by a factor of approximately 600.

Digital I/O and DAC Circuits

The digital I/O circuits interpret the control signals from the CPU (central processing unit) controller and set the input amplifier and the main amplifier to the correct configuration to perform the required measurement. The outputs from the digital I/O circuits are stored in the flip-flop registers of the miscellaneous buffer, the zero DAC (Digital to Analog Converter) buffer, and the gain/attenuator buffer.

Figure 8-13 is a simplified block diagram of the zeroing loop. When the ZERO key is pressed, or the HP-IB program code ZE is given, the software zeroing routine is initiated. The auto zeroing DAC output is used to zero the input from the power sensor with no RF signal applied. The DAC output is applied to the power sensor, is chopped in the sensor then the output from the sensor goes through the entire Power Meter amplifier chain.

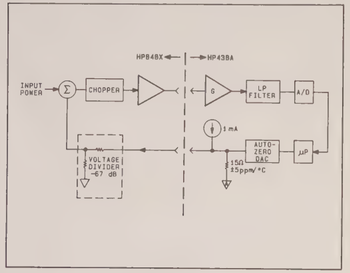


Figure 8-13. Simplified Zeroing Block Diagram

The CPU sets the output of the auto zeroing DAC to get the output from the low pass filter (Service Sheet 8) as close to zero as possible. The remaining offset is computed and stored as a series of 10 values for all combinations of the slow and fast filters and the 5 ranges. These values in conjunction with the computed DAC setting are used to determine the zero level for all input signals until the meter is zeroed again.

The stable current source supplies reference current for the zeroing DAC and the offset removal DAC.

The offset removal DAC is controlled by the CPU and subtracts the offsets introduced by the amplifier chain to produce the analog recorder output. The output of the DAC is summed with the output from the amplifier chain. The resulting signal is buffered and supplies the reference current for the gain DAC. This circuit is the hardware equivalent of the 10 computed values used by the CPU to determine the correct zeroing adjustments for the measurement that is being made.

The gain DAC is controlled by the CPU and multiplies the reference signal by some gain such that the recorder ouput equals one volt for

full scale. The setting of the gain DAC is determined at the time of calibration. The output of the DAC is buffered and applied to the rear panel RCDR (recorder) output through a 1k Ohm resistor.

Amplifier, Detector, Filter, and Comparator Circuits

The settings of the two range attenuators and the variable gain amplifier are controlled by the CPU through the gain/attenuator buffer. The range attenuators are set to match the front panel selected range if in MNL RANGE mode or the CPU selected range if in AUTO RANGE mode. The variable gain amplifier is set to provide an output from the low pass filter between 3.02 and 3.63 Vdc. The setting required is determined during calibration (CAL ADJ). Calibration is described later.

The bandpass amplifiers consist of several active stages and RC networks. The bandpass response peaks at approximately 230 Hz with 230 Hz with 0 degrees of phase shift.

The synchronous phase detector rectifies the output from the bandpass amplifier by multiplying the input by +1 or −1. Thus, the output of the detector is a signal whose filtered dc value is proportional to the true amplitude of the 220 Hz input signal.

The low pass filter consists of a slow filter and a fast filter. The input from the detector is applied to both. These filters are related to the digital filter number. If the digital filter number is 0, 1, or 2 the fast filter is active and if the number is 3 through 9 the slow filter is active. The CPU selects the output of the required filter. Which low pass filter output is selected is determined by which digital filter is selected. It is important to understand that the digital filter is not a circuit. It is an averaging function that is performed by the software and controlled by the front panel AUTO FILTER and MNL FILTER keys. The selection of the slow and fast filters is determined as follows:

1. If the digital filter number is 0, 1, or 2, the fast low pass filter (45 ms) is selected.
2. If the digital filter number is 3 through 9, the slow low pass filter (800 ms) is selected.

A detailed description of digital filtering is provided later on this service sheet. The output of the low pass filter is buffered and applied to the following two circuits:

1. The summing point of the offset removal DAC (Service Sheet 7). The use of this output was described previously.
2. The Analog/Digital Input Multiplexer.

The Analog/Digital Multiplexer can select any one of the following signals as the ADC (analog to digital converter) input to the comparator:

1. The low pass filter output.

2. The front and or rear sensor resistors for sensors connected to channels A or B.
3. The B-GND (0V).
4. The auto zero DAC output (this signal is only selected for testing).
5. The offset removal DAC output (this signal is selected during the zeroing routine).
6. The gain DAC output (this signal is only selected during the calibration routine).

The Analog-to-Digital Converter (ADC) in the Power Meter consists of the following three parts:

1. The ramp generator and comparator circuits in the main amplifier.
2. The timer A/D and software interrupt circuit in the CPU.
3. The software routine that controls these circuits.

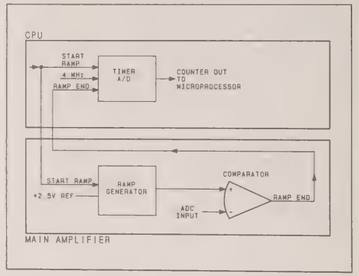


Figure 8-14. Simplified Analog to Digital (A/D) Converter Block Diagram

Figure 8-14 Simplified A/D Converter Block Diagram shows the relationship between the CPU and the main amplifier circuits. The method of digitizing the input signal is identical for all input signals. The sequence is as follows:

1. The selected signal from the analog/digital input multiplexer is applied to the ADC input of the comparator.
2. The CPU generates the start ramp signal. This signal is applied simultaneously to the timer A/D in the CPU and the ramp generator in the main amplifier.
3. The timer A/D starts counting at a 4 MHz rate.
4. Using the 2.5V reference input, the ramp generator produces a linear positive ramp.
5. When the ramp voltage equals the ADC input voltage, the comparator sends the ramp end signal to the timer A/D circuit in the CPU. The counter is stopped at the count that represents the value of the ADC input signal. This information is used by the microprocessor to compute the measurement value. This value can then be used in any other computations required to obtain the final displayed information.

1 mW 50 MHz Power Reference Circuit

The G1 50 MHz Reference Oscillator provides a 50.0 ± 0.5 MHz output at 1.0 mW ± 0.7%. This output is used during operation to calibrate the individual power sensors used with the Power Meter. It can also be used during the Operator's Check and troubleshooting procedures as a signal source.

As explained previously, the zeroing software routine determines the setting for the auto zero DAC, calulates and stores 10 offset values for the 10 combinations of the two low pass filters and the five available ranges. For correct calibration, the connected power sensor and the Power Meter must be zeroed prior to calibration.

The main functions of the power sensor calibration software routine are as follows:

1. Verify an appropriate power source and a power sensor are connected to the Power Meter. In some cases, the power source is the Power Meter's 1 mW 50 MHz Reference output.
2. Set the range attenuators and the low pass and digital filters to the correct settings for the connected power sensor.
3. Set the variable gain amplifier so that the ADC output indicates between 3.02 and 3.63 Vdc.
4. Calculate and scale the 10 zeroing offset values to provide more accurate power measurements.
5. Calculate the offset DAC settings to match these new values.
6. Find the gain DAC settings required to provide a full scale 1 Vdc output at the rear panel RCDR (recorder) connector.

After the power sensor and Power Meter are correctly zeroed and calibrated, they can be used to make power measurements within the specified parameters of the combined instruments.

Digital Filter Software Routine (Digital Filter)

The most important point to understand about the digital filter is that it is a software routine and not a hardware component. It does, however, have a direct bearing on the selection of the slow or fast low pass filter. The selected combination of these two filters determine the speed, resolution, and stability (jitter) of the final measurement result.

The digital filter is an averaging filter. The value returned by the digital filter is the average of the last N power readings, where N is the filter length. The filter length is determined by two being raised to some power where that power is the filter range number zero through nine. The filter number can be manually selected using the front panel MNL FILTER key or automatically selected by the software if the AUTO FILTER key is active. The relationship between the selected filter number and the filter length is as follows:

FILTER NUMBER	FILTER LENGTH (Number of Readings)
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512

SERVICE SHEET BD3 (cont'd)

TROUBLESHOOTING HINTS

The troubleshooting checks on this service sheet are used to narrow down a malfunction to one of the following assemblies: A4 Input Amplifier Assembly, A5 Main Amplifier Assembly, and G1 50 MHz Reference Oscillator. The major part of this service sheet is the A5 Main Amplifier Assembly and its schematic diagrams are on Service Sheets 7 and 8. The A4 Input Amplifier Assembly schematic diagram is on Service Sheet 6 and G1 50 MHz Reference Oscillator schematic diagram is on Service Sheet 11.

The checks will cover selected inputs and outputs of these major assemblies. The checks attempt to verify a good interface between the power sensor and the input amplifier so that the zeroing loop is completed and that analog to digital conversion (ADC) is being accomplished by the CPU and main amplifier connections.

Test Equipment

Oscilloscope	HP 1740A
Power Sensor	HP 8480 series
Sensor Cable	HP 11730A
Digital Voltmeter (DVM)	HP 3456A

POWER SENSOR TO FIRST AMPLIFIER INTERFACE CHECK

Assuming at this point that BD1 Amplifier Section (√3) has been completed and the comparator output RAMP END signal was incorrect or that the RCDR (rear panel recorder) BNC output is not 1 Vdc.

Connect power sensor to channel A or channel B and the 1 mW POWER REF. The normal indication is:

1. The display should indicate 1.000 -3 WATT (mW) and channel A or B depending on the active channel.

Abnormal Indication. If any abnormal indication occurs:

1. The selected amplified ac is not as shown in Figure 8-15 at test point A4TP3 or A4TP4 depending on which channel is active. Refer to A4 Input Amplifier Assembly on Service Sheet 6.

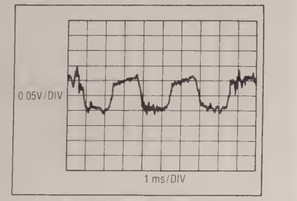


Figure 8-15. Selected Amplified AC

2. The phase detector drive is not as shown in Figure 8-16 at test point A4TP5 or A4TP6. Refer to A4 Input Amplifier Assembly on Service Sheet 6.

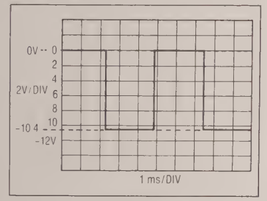


Figure 8-16. Phase Detector Drive

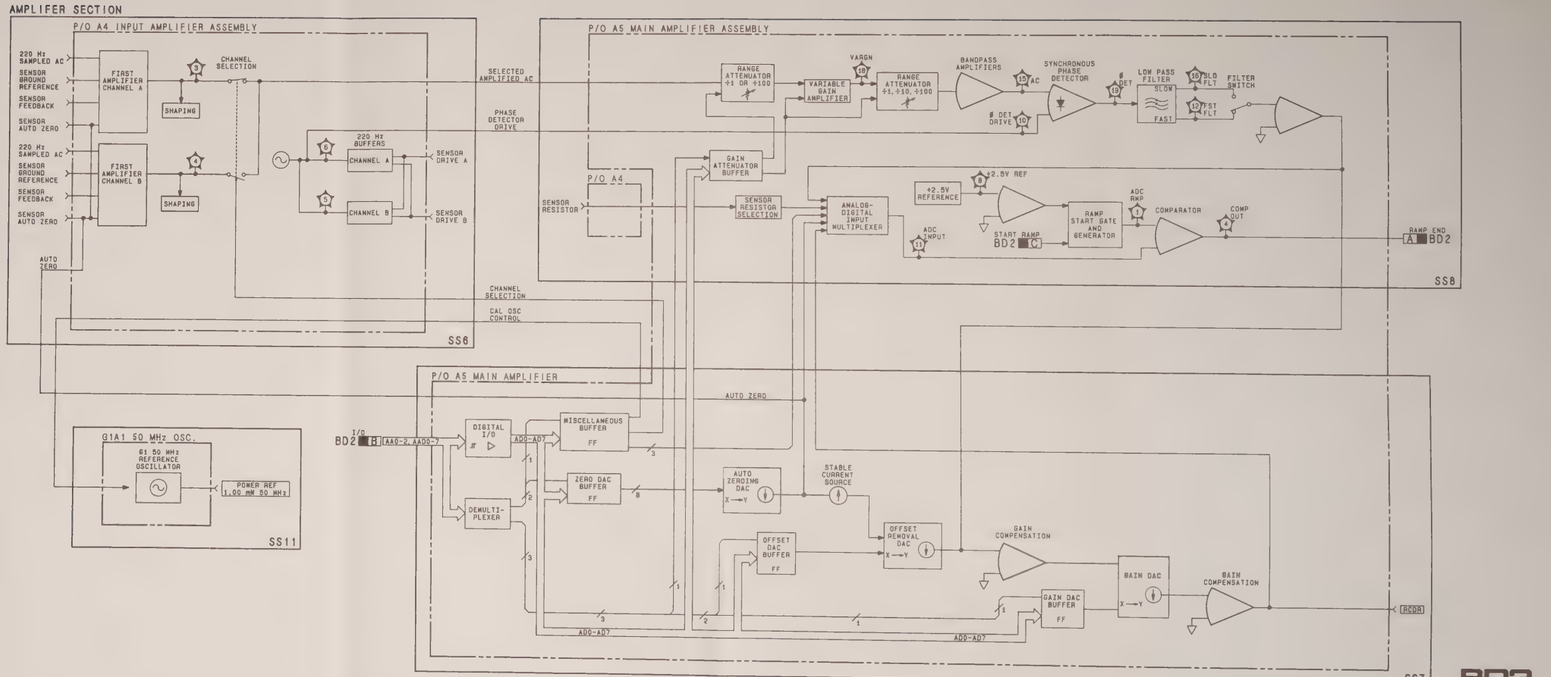


Figure 8-17. Amplifier Section Block Diagram

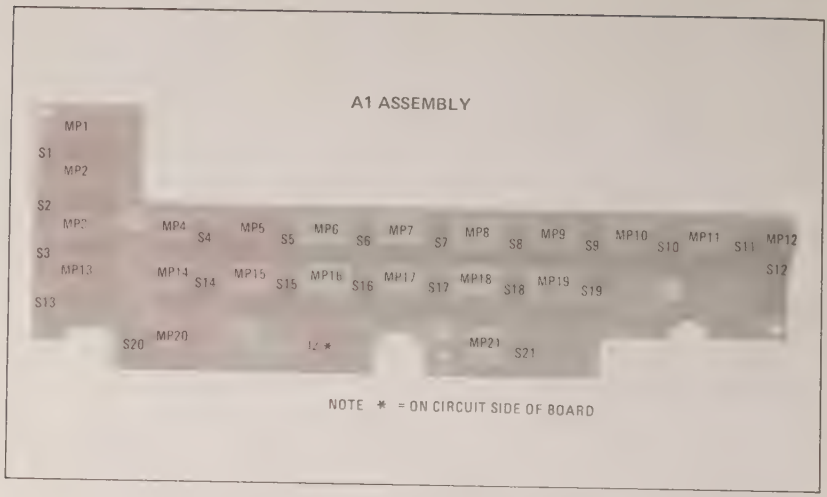


Figure 8-18. Keyboard Assembly Component Locations

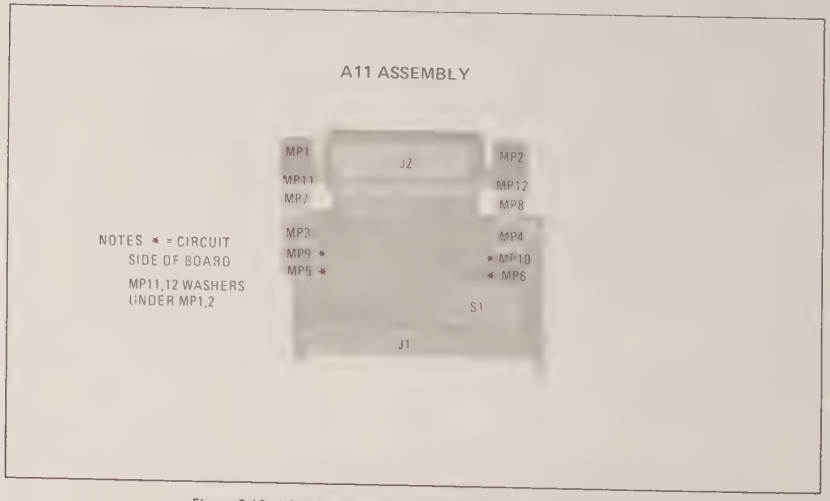


Figure 8-19. HP-IB Connector Board Assembly Component Locations

Amplifier Section Block Diagram SERVICE SHEET BD3

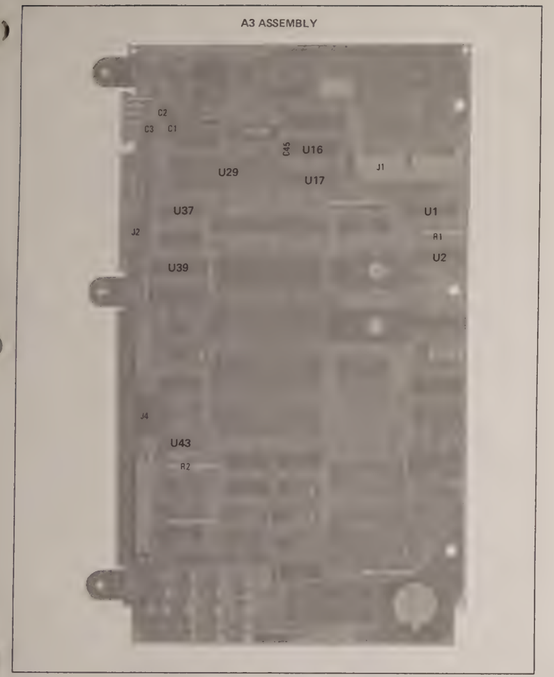


Figure 8-20. Central Processing Unit Assembly Component Locations

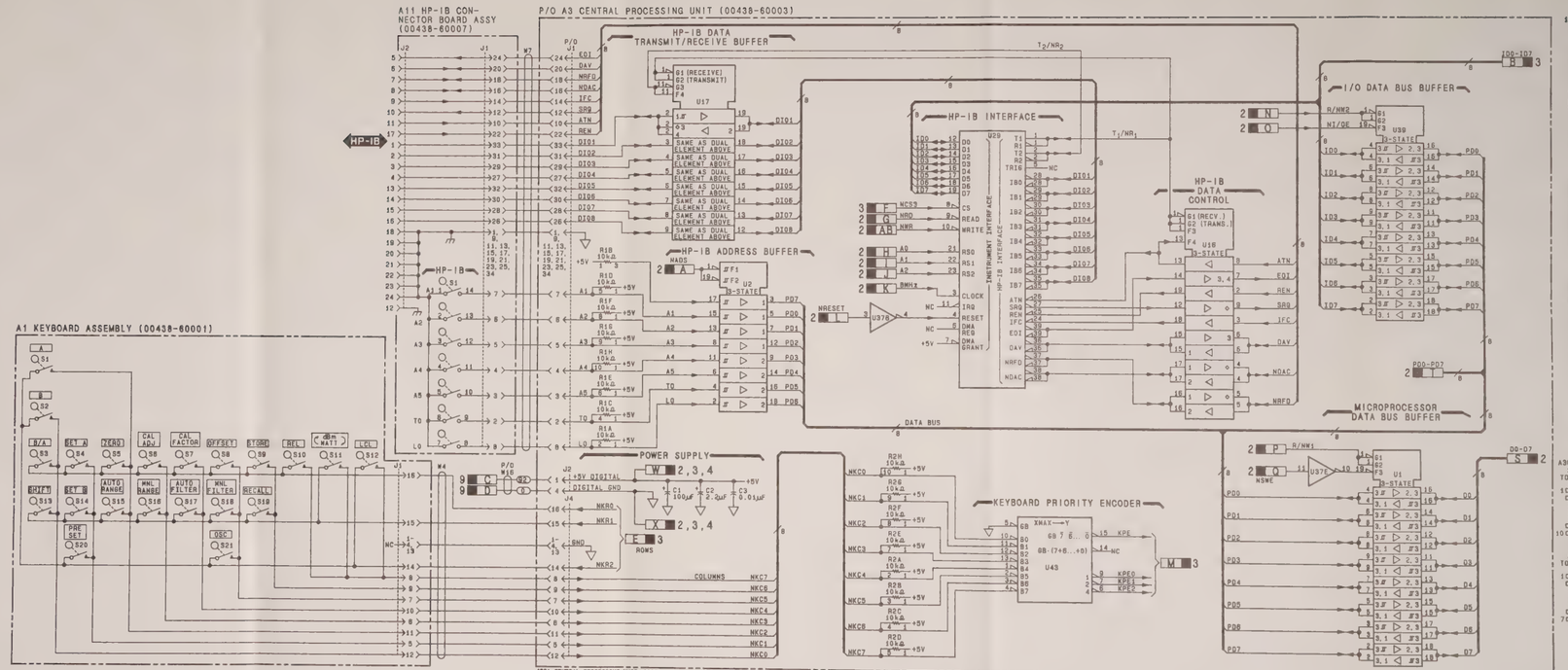


Figure 8-21. Data Input/Output Circuits Schematic Diagram

Data Input/Output
Circuits
SERVICE SHEET
1

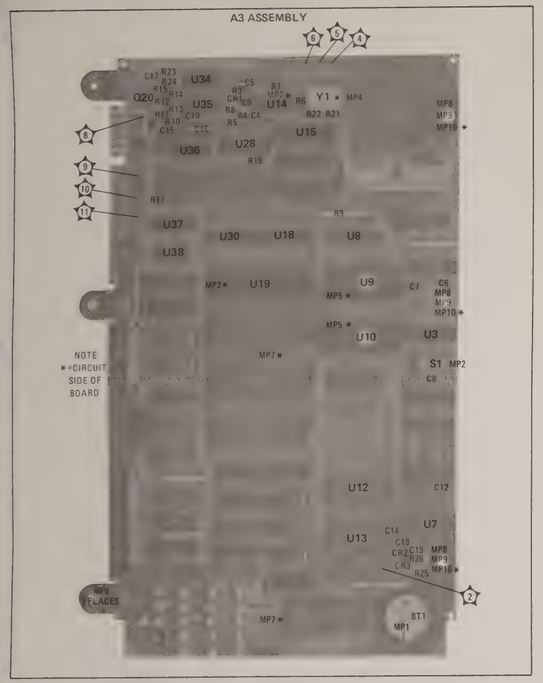
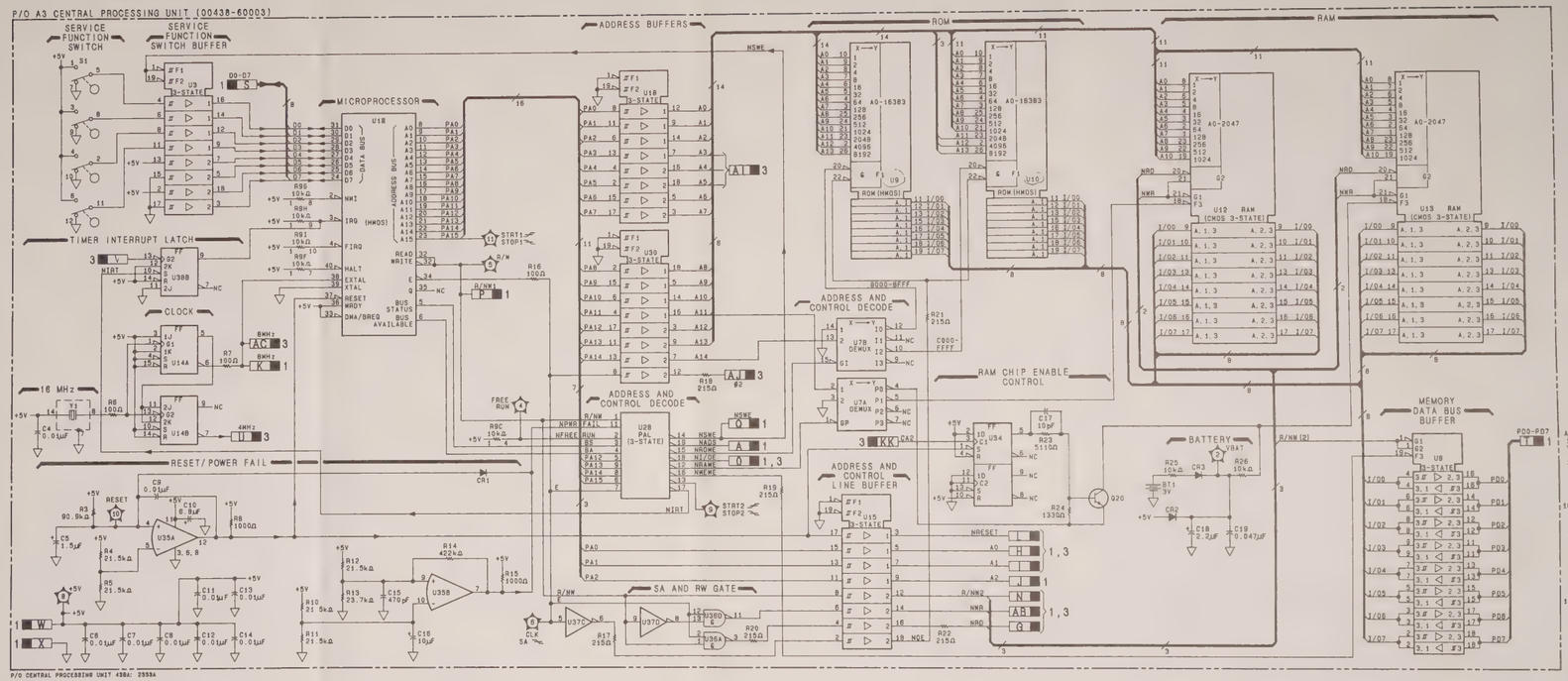


Figure 8-22. P/O Central Processing Unit Assembly Component Locations



NOTES

1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

A3	A3 CONT.
B11	TP2, 4-6, 8-14
C4-19	U3, 7-15, 12-15, 18, 28, 30, 34-38
CR1-3	Y1
Q20	
R3-26	
S1	

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
Q20	1854-0477
U3, 15, 18, 30	1820-2024
U7	1820-1281
U8	1820-2075
U9	00438-80002
U10	00438-80003
U12, 13	1818-1768
U14, 38	1820-1212
U19	1820-2624
U28	00438-80001
U34	1820-1753
U35	1826-0175
U36	1820-1197
U37	1820-1199

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U3, 8, 15, 18, 28, 30	+5V - 20 GND - 10
U7, 14, 38	+5V - 16 GND - 8
U8, 10	+5V - 1, 28 GND - 14
U12	+5V - 24 GND - 8
U13	+5V (FU) - 24 GND - 8
U19	+5V - 7 GND - 1
U34, 36, 37	+5V - 14 GND - 7

LOGIC LEVELS

	TTL	CMOS
HIGH	>2V	>3.5V
LOW	<0.8V	<1.5V
< IS MORE NEG. THAN		
> IS MORE POS. THAN		
OPEN	HIGH	UNDEF.
GROUND	LOW	LOW

A3U3, 8, 15, 18, 28, 30 TOP VIEW

A3U7, 14, 38 TOP VIEW

A3U8, 10 TOP VIEW

A3U12, 13 TOP VIEW

A3U34, 36, 37 TOP VIEW

A3U19 TOP VIEW

A3P9

PIN NO.	1	2	3	4	5	6	7	8	9	10
COMMON	A	B	C	D	E	F	H	J	K	L

2
P/O A3

Figure 8-23. Figure 8-23. Microprocessor and Memory Circuits

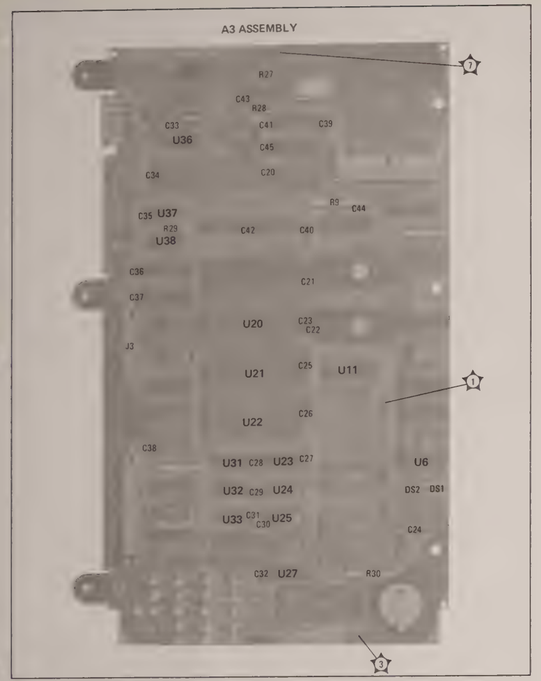


Figure 8-24. P/O Central Processing Unit Assembly Component Locations

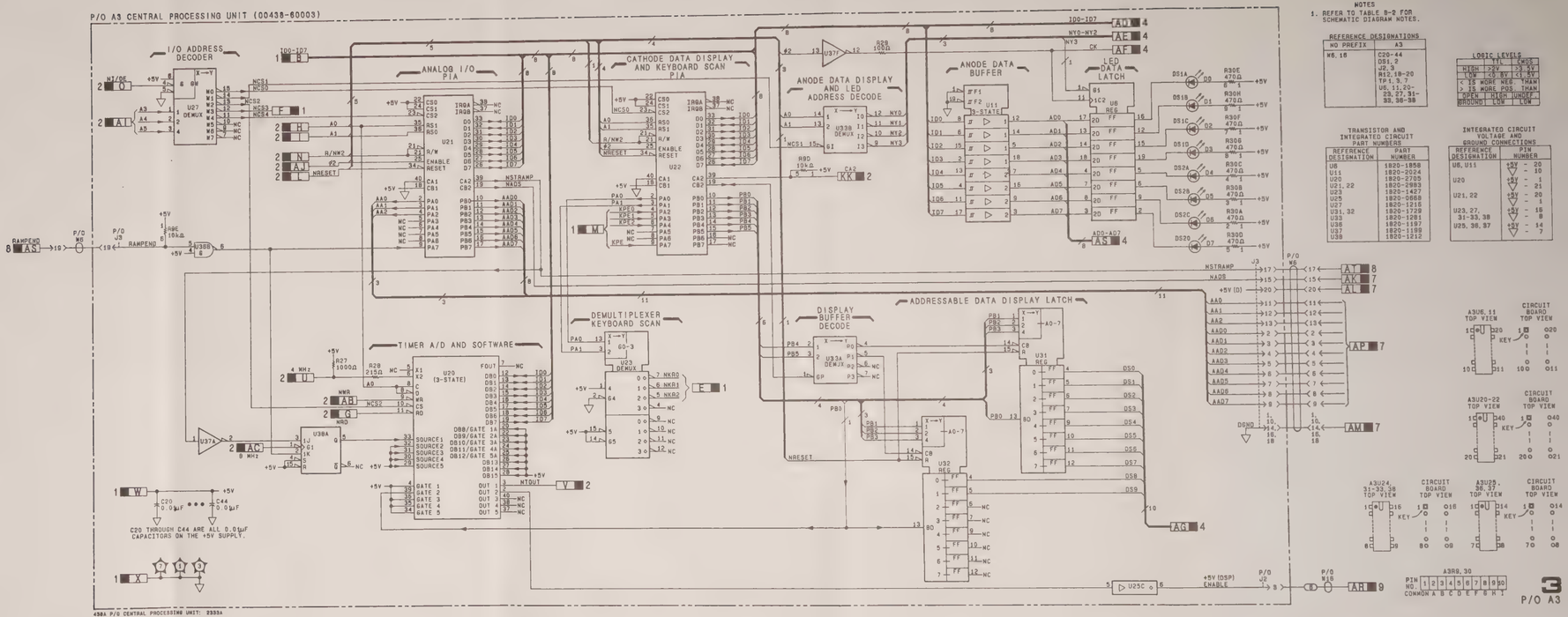


Figure 8-25. Timer and Peripheral Interface Adapter (PIA) Circuits Schematic Diagram

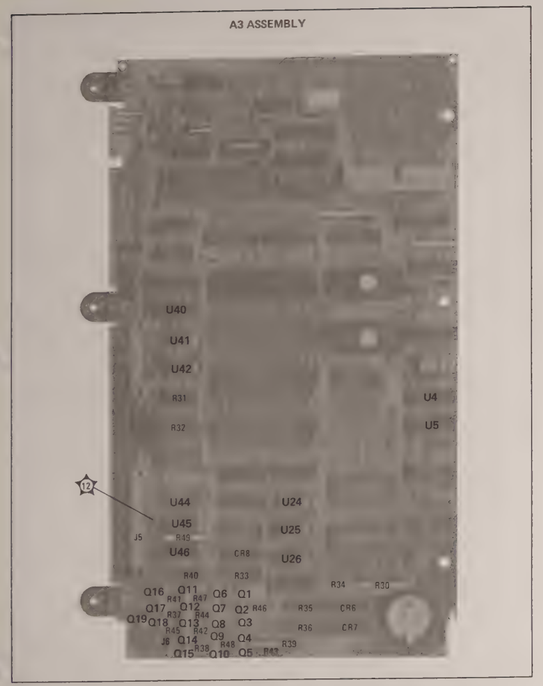
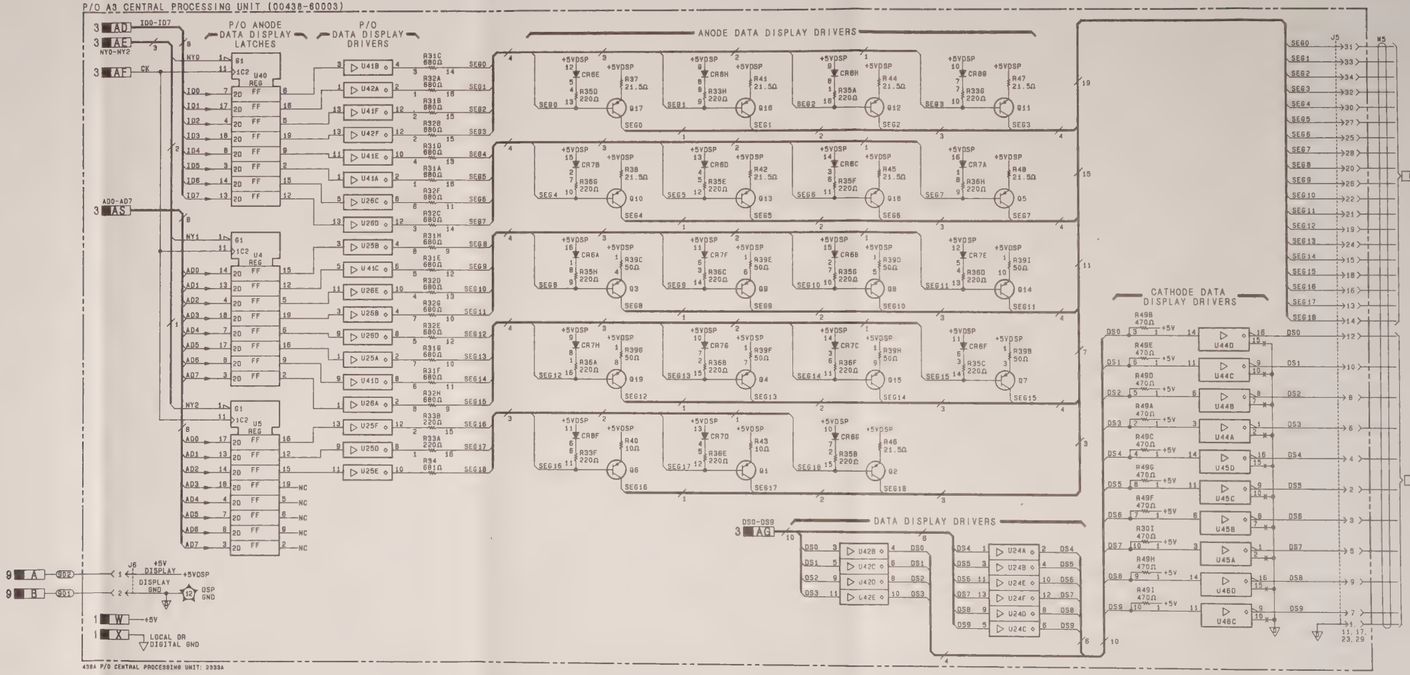


Figure 8-26. P/O Central Processing Unit Assembly Component Locations



NOTES

1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS	
MC PREFIX	A3
M5	CR6-8 J5,6 R1-19 R31-49 U4,5,24-26, 40-42,44- 46

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
Q1-19	1853-0281
U4,5,40	1820-1858
U24,25,26, 41,42	1820-0868
U44-46	1820-2130

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U4,5,40	+5V - 20 GND - 10
U24,25,26, 41,42	+5V - 14 GND - 7

LOGIC LEVELS

	TTL	CMOS
HIGH	>2V	>3.5V
LOW	<0.8V	<1.5V
< IS MORE NEG. THAN		
> IS MORE POS. THAN		
OPEN	HIGH	UNDEF.
GROUND	LOW	

A3R30, 39, 49
PIN NO. 1 2 3 4 5 6 7 8 9 10
COMMON A B C D E F G H J

A3R31-33, 35, 36
1 2 3 4 5 6 7 8
A B C D E F G H
16 15 14 13 12 11 10 9

A3CR6-8
16 15 14 13 12 11 10 9
A B C D E F G H
1 2 3 4 5 6 7 8

A3U1-19 TOP VIEW
A3U4, 5, 41 TOP VIEW
A3U24, 25, 26 41, 42 TOP VIEW
A3U44-46 TOP VIEW
CIRCUIT BOARD TOP VIEW
KEY

Figure 8-27. Display Driver Circuits Schematic Diagram

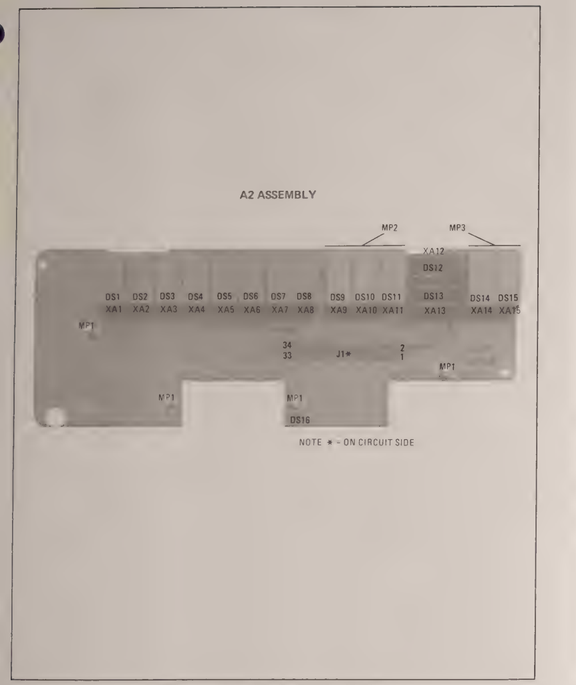


Figure 8-28. Display Assembly Component Locations

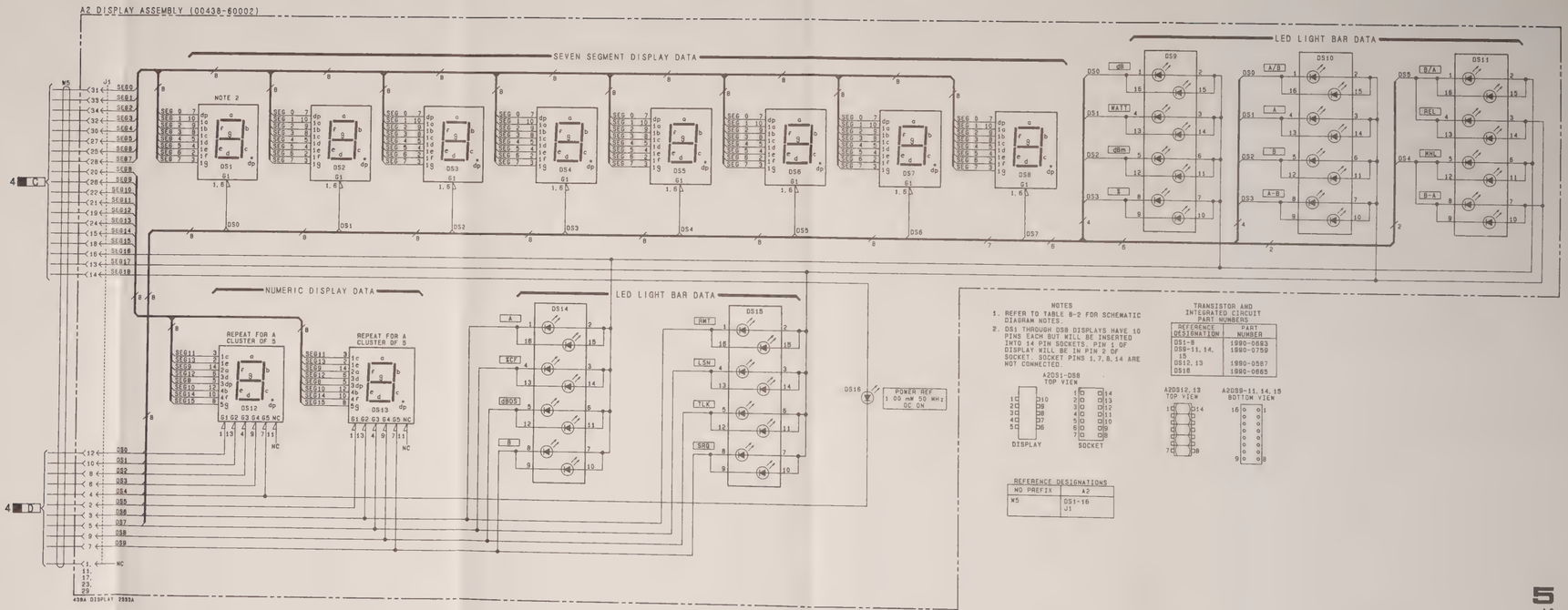


Figure 8-29. Front Panel Display Circuits Schematic Diagram

Front Panel
Display Circuits
SERVICE SHEET 5

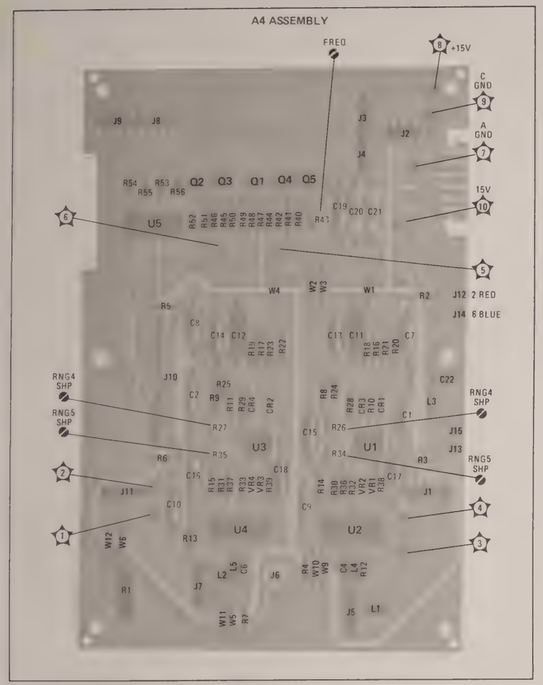
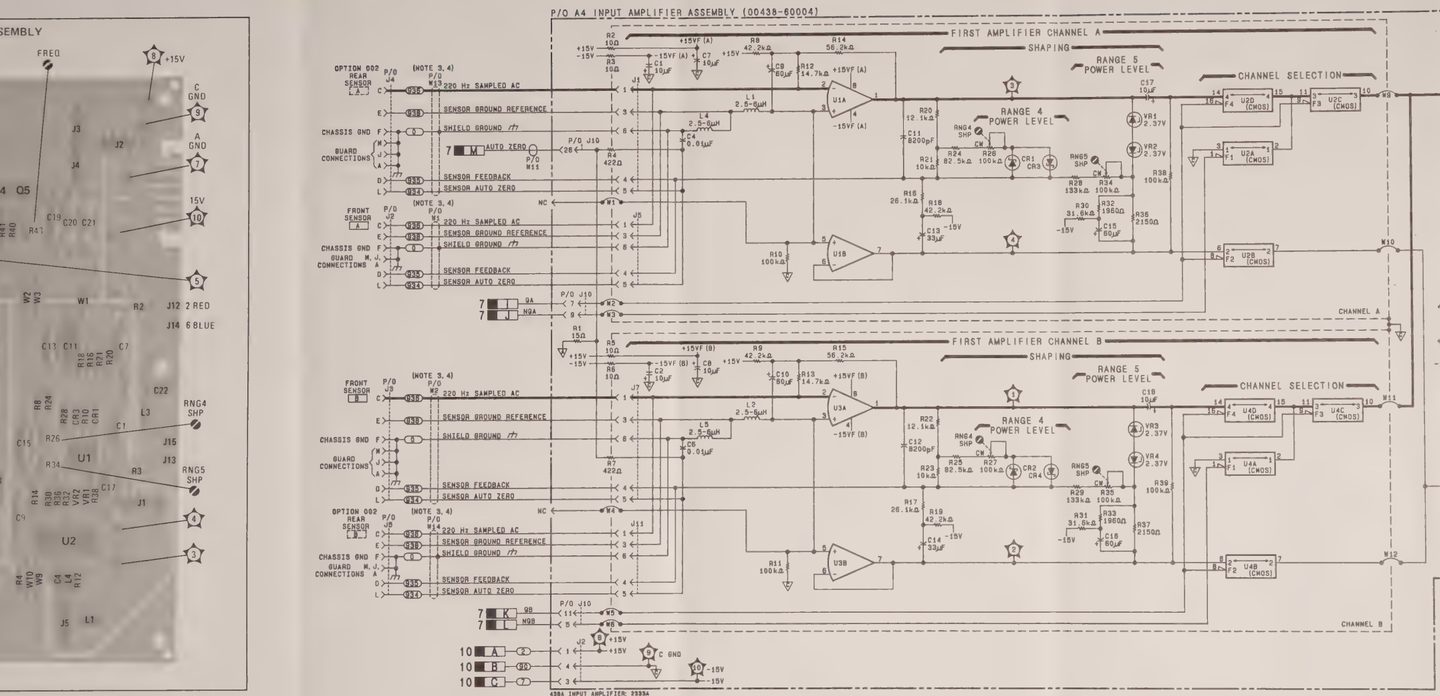


Figure 8-30. Input Amplifier Assembly Component Locations



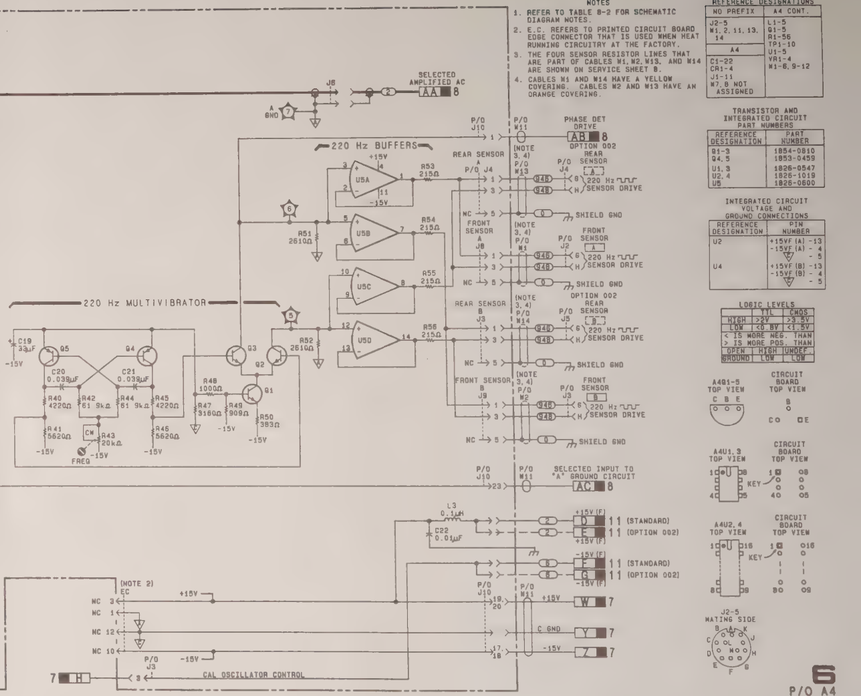

NOTES
1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.
2. E.C. REFERS TO PRINTED CIRCUIT BOARD EDGE CONNECTOR THAT IS USED WHEN HEAT RUNNING CIRCUITRY AT THE FACTORY.
3. THE FOUR SENSOR RESISTOR LINES THAT ARE PART OF CABLES W1,W2,W13, AND W14 ARE SHOWN ON SERVICE SHEET 8.
4. CABLES W1 AND W14 HAVE A YELLOW COVERING. CABLES W2 AND W13 HAVE AN ORANGE COVERING.
220 Hz BUFFERS
220 Hz MULTIVIBRATOR
PHASE DET DRIVE
REAR SENSOR
FRONT SENSOR
SELECTED AMPLIFIED AC
SELECTED INPUT TO "A" GROUND CIRCUIT
CAL OSCILLATOR CONTROL
SHIELD GND
220 Hz SENSOR DRIVE
+15V (STANDARD)
+15V (OPTION 002)
-15V (STANDARD)
-15V (OPTION 002)
C GND
REFERENCE DESIGNATIONS
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS
INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS
LOGIC LEVELS
CIRCUIT BOARD TOP VIEW
J2-5 MATING SIDE
6
P/O A4

Figure 8-31. Input Amplifier Circuits Schematic Diagram

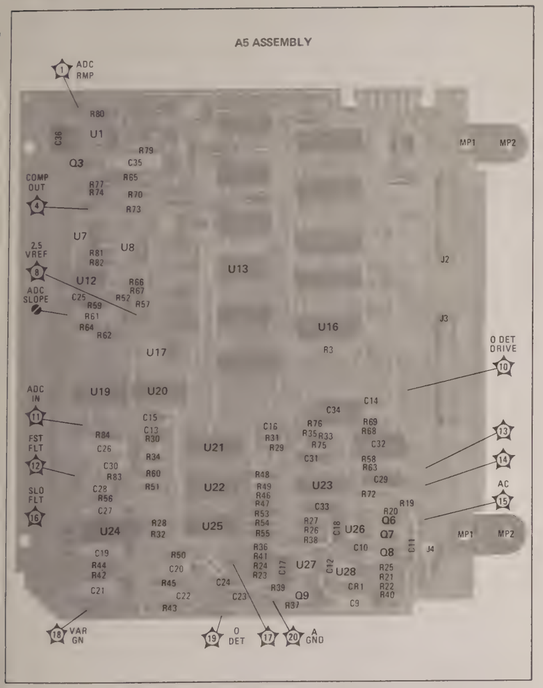


Figure 8-32. P/O Main Amplifier Assembly Component Locations

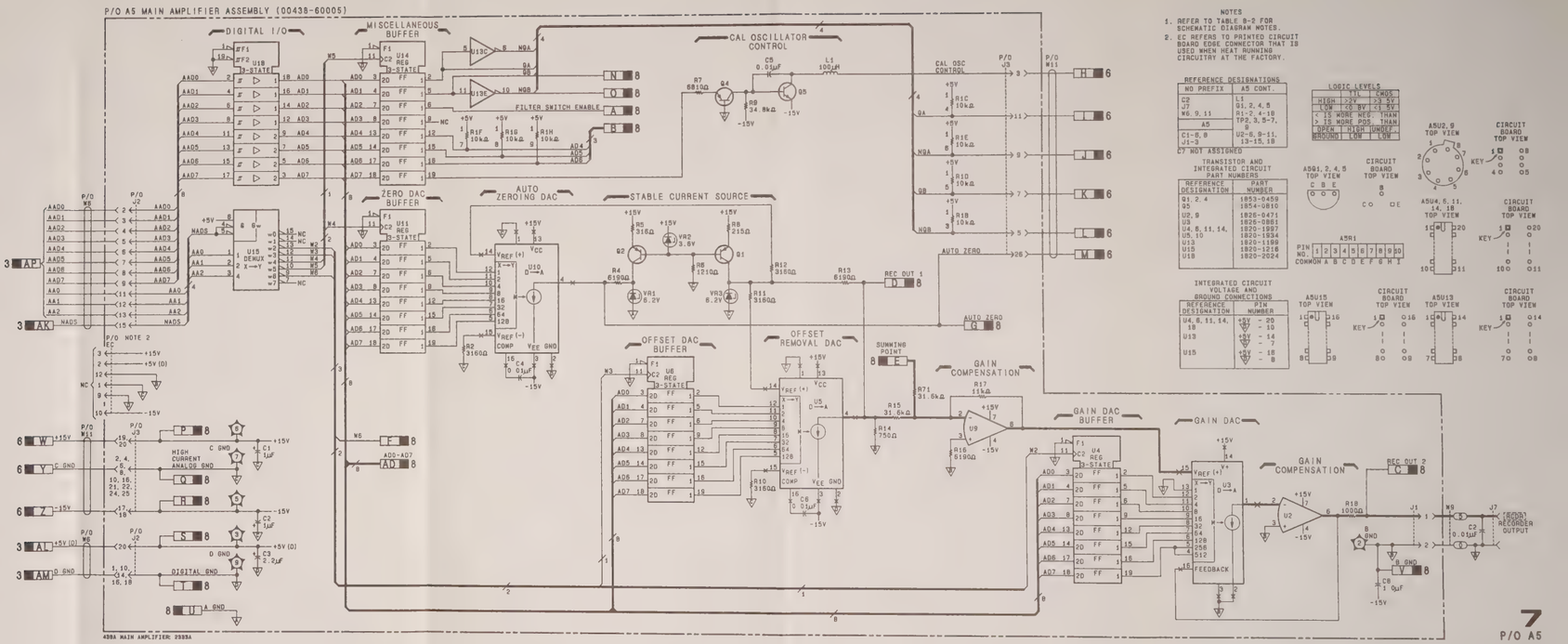


Figure 8-33. P/O Main Amplifier Circuits Schematic Diagram

P/O Main Amplifier
Circuits
SERVICE SHEET 7

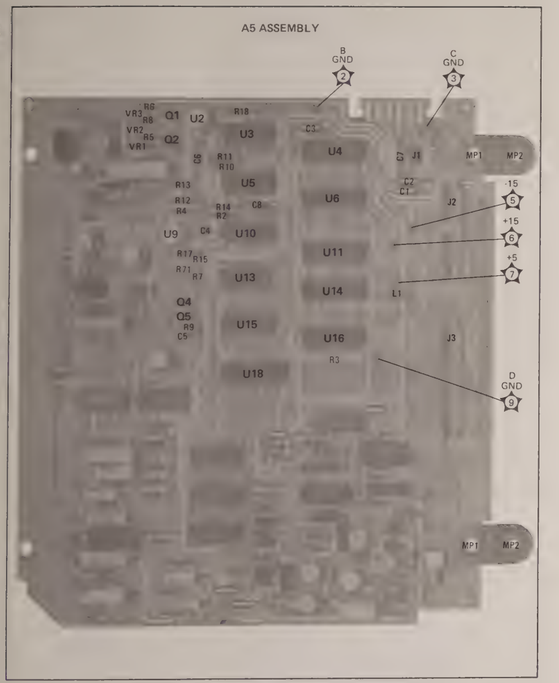


Figure 8-34. P/O A5 Main Amplifier Assembly Component Locations

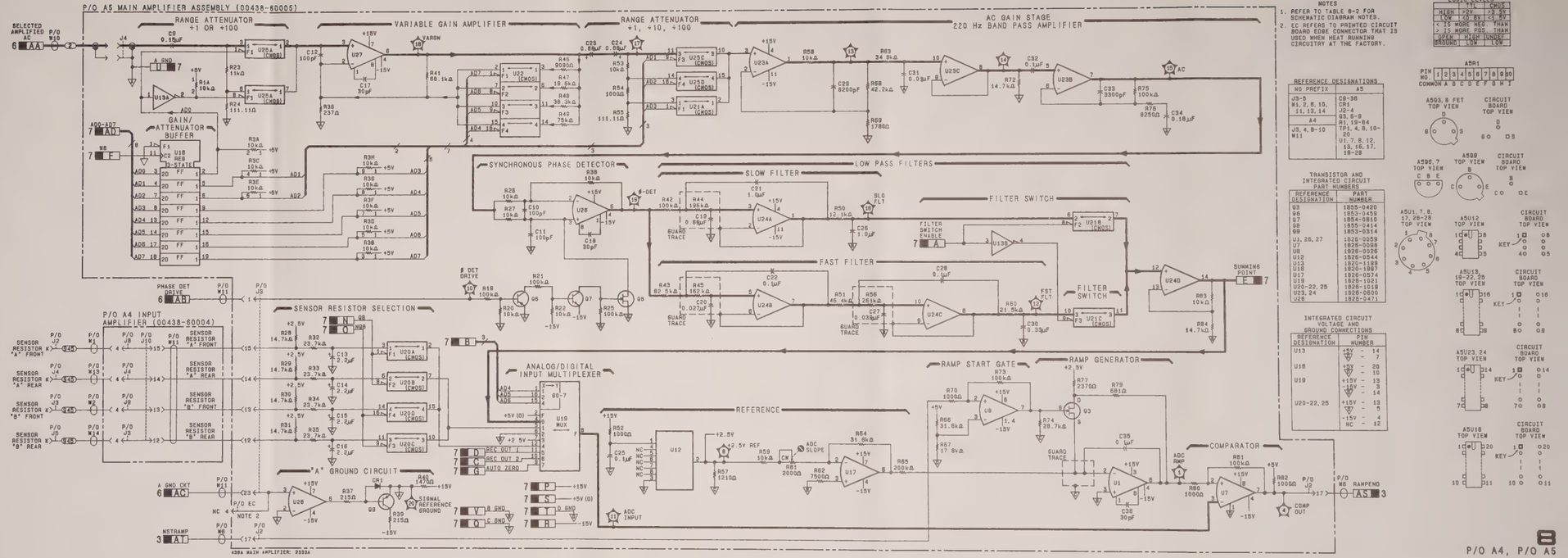

P/O A5 MAIN AMPLIFIER ASSEMBLY (00438-60005)
RANGE ATTENUATOR ±1 OR ±100
VARIABLE GAIN AMPLIFIER
RANGE ATTENUATOR ±1, ±10, ±100
AC GAIN STAGE 220 Hz BAND PASS AMPLIFIER
GAIN/ ATTENUATOR BUFFER
SYNCHRONOUS PHASE DETECTOR
SLOW FILTER
LOW PASS FILTERS
FAST FILTER
FILTER SWITCH
SENSOR RESISTOR SELECTION
P/O A4 INPUT AMPLIFIER (00438-60004)
ANALOG/DIGITAL INPUT MULTIPLEXER
REFERENCE
RAMP START GATE
RAMP GENERATOR
COMPARATOR
"A" GROUND CIRCUIT
SIGNAL REFERENCE GROUND
SUMMING POINT
NOTES
1. REFER TO TABLE 6-2 FOR SCHEMATIC DIAGRAM NOTES.
2. EC REFERS TO PRINTED CIRCUIT BOARD EDGE CONNECTOR THAT IS USED WHEN HEAT RUNNING CIRCUITRY AT THE FACTORY.
LOGIC LEVELS
REFERENCE DESIGNATIONS
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS
INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS
A5R1
A5U1, 7, 8, 17, 26-28 TOP VIEW
A5U2 TOP VIEW
A5U3, 19-22, 25 TOP VIEW
A5U23, 24 TOP VIEW
A5U18 TOP VIEW
A5Q3, 8 FET TOP VIEW
A5Q6, 7 TOP VIEW
A5Q9 TOP VIEW
CIRCUIT BOARD TOP VIEW
438A MAIN AMPLIFIER: 2533A

Figure 8-35. P/O Main Amplifier Circuits Schematic Diagram

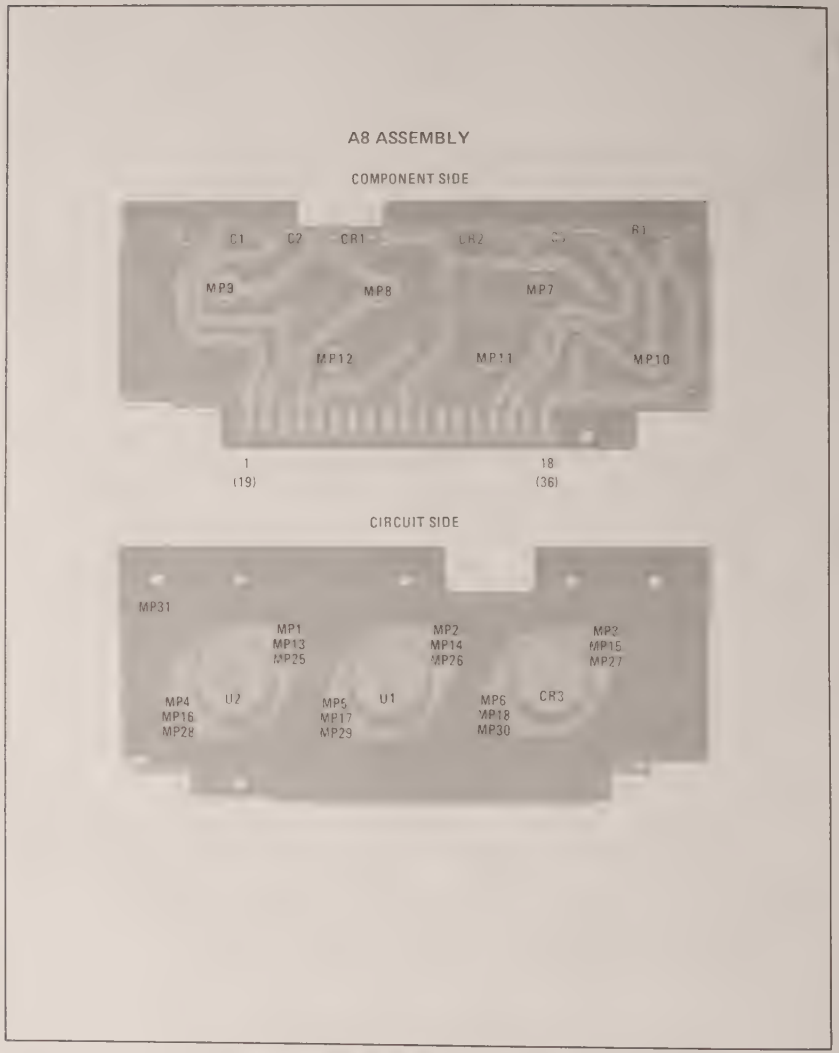


Figure 8-36. Rectifier Assembly Component Locations

P/O Main Amplifier Circuits SERVICE SHEET 8

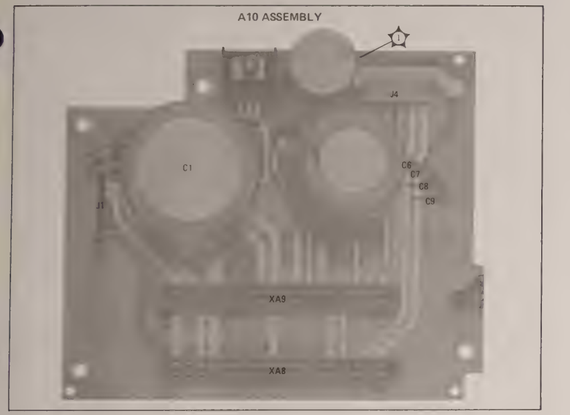


Figure 8-37. P/O Interconnect Assembly Component Locations

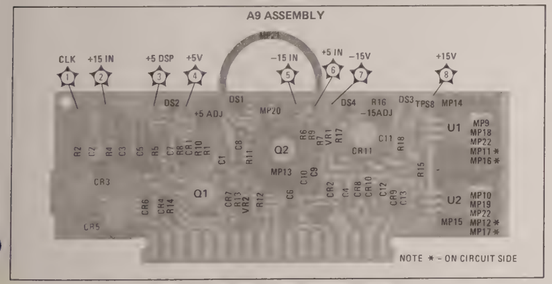
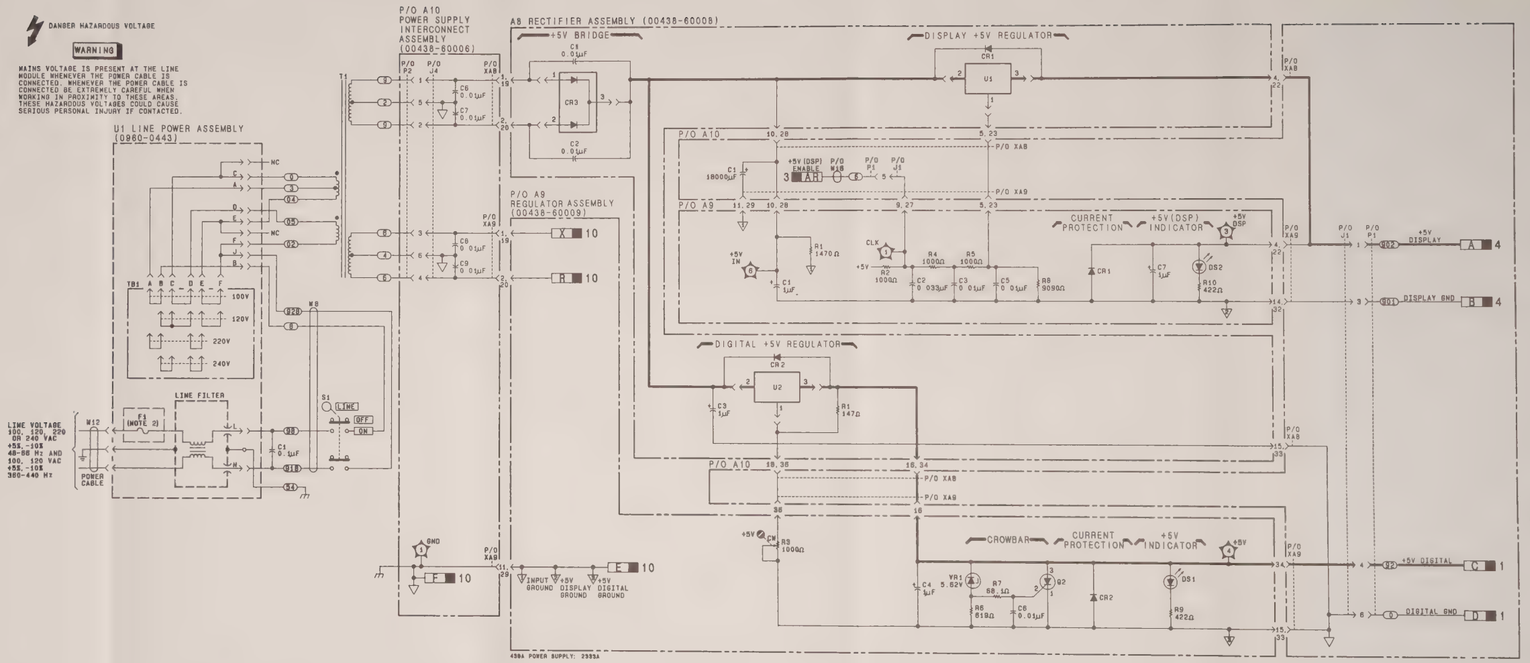


Figure 8-38. Regulator Assembly Component Locations


DANGER HAZARDOUS VOLTAGE
WARNING
MAINS VOLTAGE IS PRESENT AT THE LINE MODULE WHENEVER THE POWER CABLE IS CONNECTED. WHENEVER THE POWER CABLE IS CONNECTED BE EXTREMELY CAREFUL WHEN WORKING IN PROXIMITY TO THESE AREAS. THESE HAZARDOUS VOLTAGES COULD CAUSE SERIOUS PERSONAL INJURY IF CONTACTED.
P/O A10 POWER SUPPLY INTERCONNECT ASSEMBLY (00438-60006)
A8 RECTIFIER ASSEMBLY (00438-60008)
+5V BRIDGE
DISPLAY +5V REGULATOR
U1 LINE POWER ASSEMBLY (0960-0443)
P/O A9 REGULATOR ASSEMBLY (00438-60009)
DIGITAL +5V REGULATOR
CROWBAR
CURRENT PROTECTION
+5V(DSP) INDICATOR
+5V INDICATOR
TB1
100V
120V
220V
240V
LINE FILTER
F1 (NOTE 2)
S1
LINE VOLTAGE 100, 120, 220 OR 240 VAC +5%, –10% 48–66 Hz AND 100, 120 VAC +5%, –10% 360–440 Hz
POWER CABLE
+5V DISPLAY
DIGITAL GND
INPUT GROUND
4304 POWER SUPPLY: 23934

NOTES
1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.
2. VALUE OF F1 IS:
   1.0A FOR A LINE VOLTAGE OF 100–120 VAC
   500 mA 250V FOR A LINE VOLTAGE OF 200–240 VAC.

REFERENCE DESIGNATIONS

NO PREFIX	A8
C1	C1–7
S1	CR1, 2
T1	DS1, 2
U1	Q2
W8, 12	R1–10
	TP1, 3, 4, 6
A8	VR1
	A10
C1–3	C1, 6–9
CR1–3	J3, 4
R1	TP1
U1, 2	XA8, XA9

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
A8	
U1	1826-0423
U2	1826-0877
A8Q2	1884-0244

A8CR1 BOTTOM VIEW
ANODE
ANODE
CASE COMMON CATHODE

A8U1, 2 BOTTOM VIEW
CASE

A8Q2 BOTTOM VIEW
GATE
CATHODE
CASE ANODE

CIRCUIT BOARD TOP VIEW

Figure 8-39. P/O Power Supply Circuits Schematic Diagram

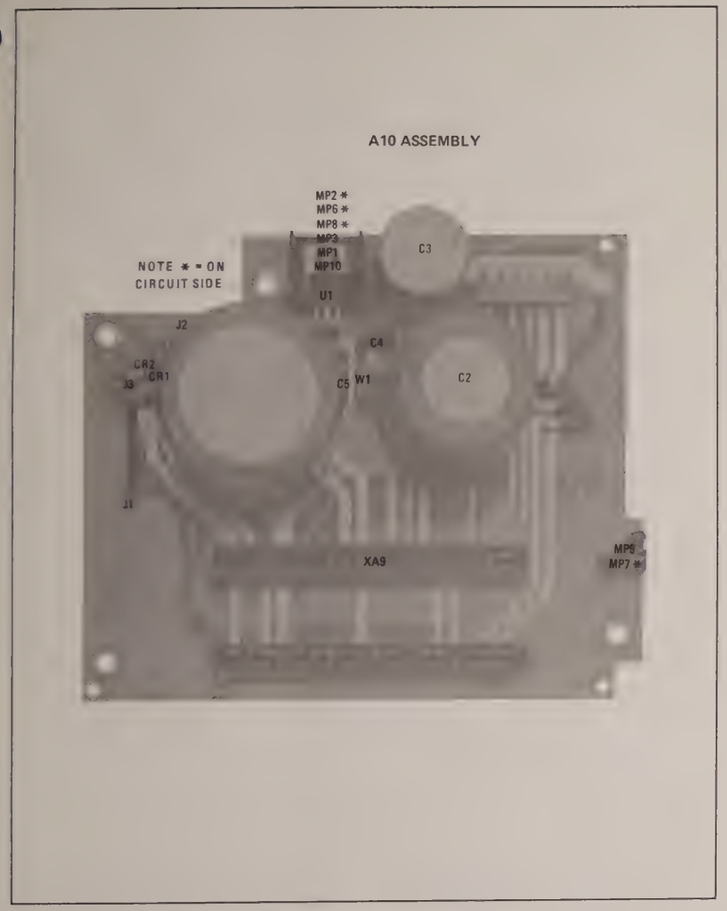
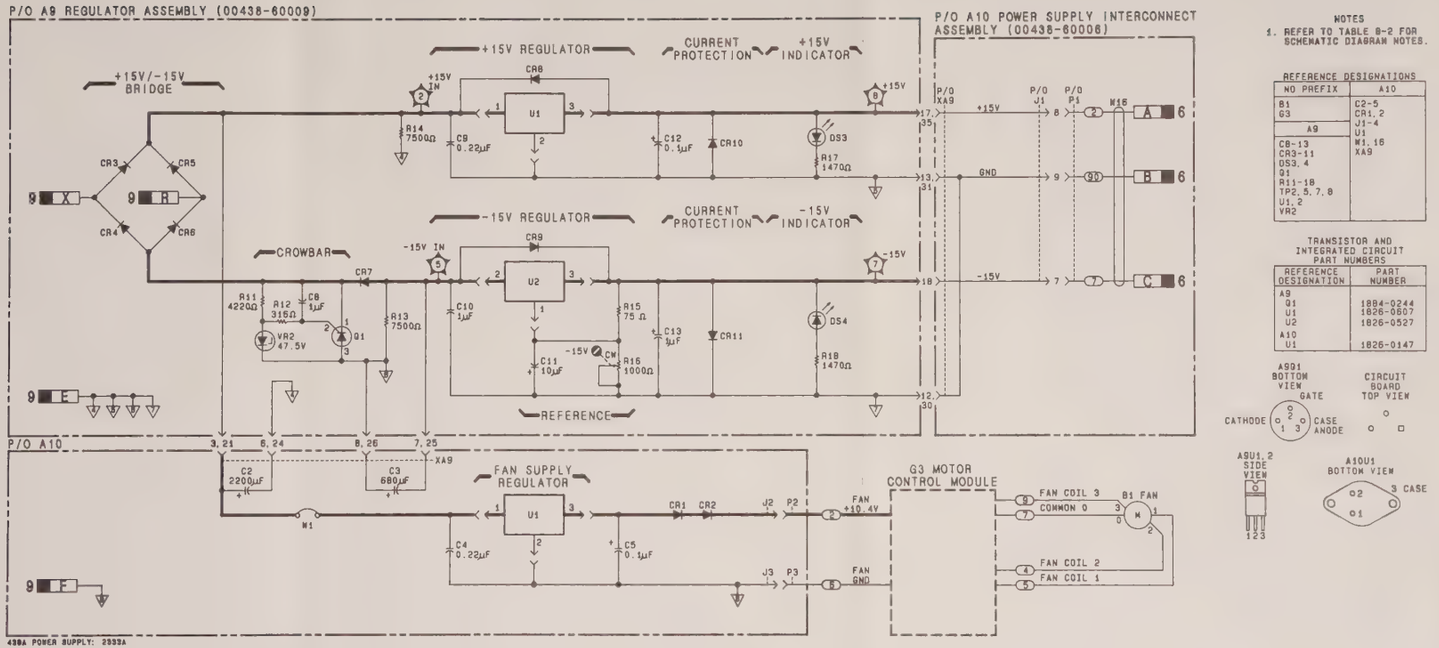


Figure 8-40. P/O Interconnect Assembly Component Locations



NOTES
1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS	
NO PREFIX	A10
B1	C2-5
G3	CR1, 2
	J1-4
A9	U1
C8-13	W1, 16
CR3-11	XA9
DS3, 4	
Q1	
R11-18	
TP2, 5, 7, 8	
U1, 2	
VR2	

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
A9	
Q1	1884-0244
U1	1826-0807
U2	1826-0527
A10	
U1	1826-0147

A9U1 BOTTOM VIEW — GATE, CATHODE, CASE, ANODE

CIRCUIT BOARD TOP VIEW

A9U1, 2 SIDE VIEW

A10U1 BOTTOM VIEW — CASE

P/O A9, P/O A10, G3

Figure 8-41. P/O Power Supply Circuits Schematic Diagram

P/O Power Supply
Circuits
SERVICE SHEET 10

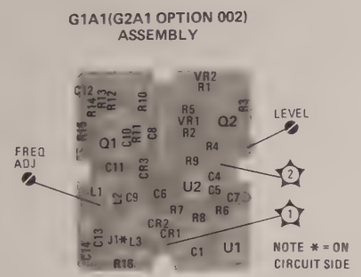


Figure 8-42. G1A1 (G2A1 Option 002) Power Reference Oscillator Assembly Component, Test Point, and Adjustment Locations

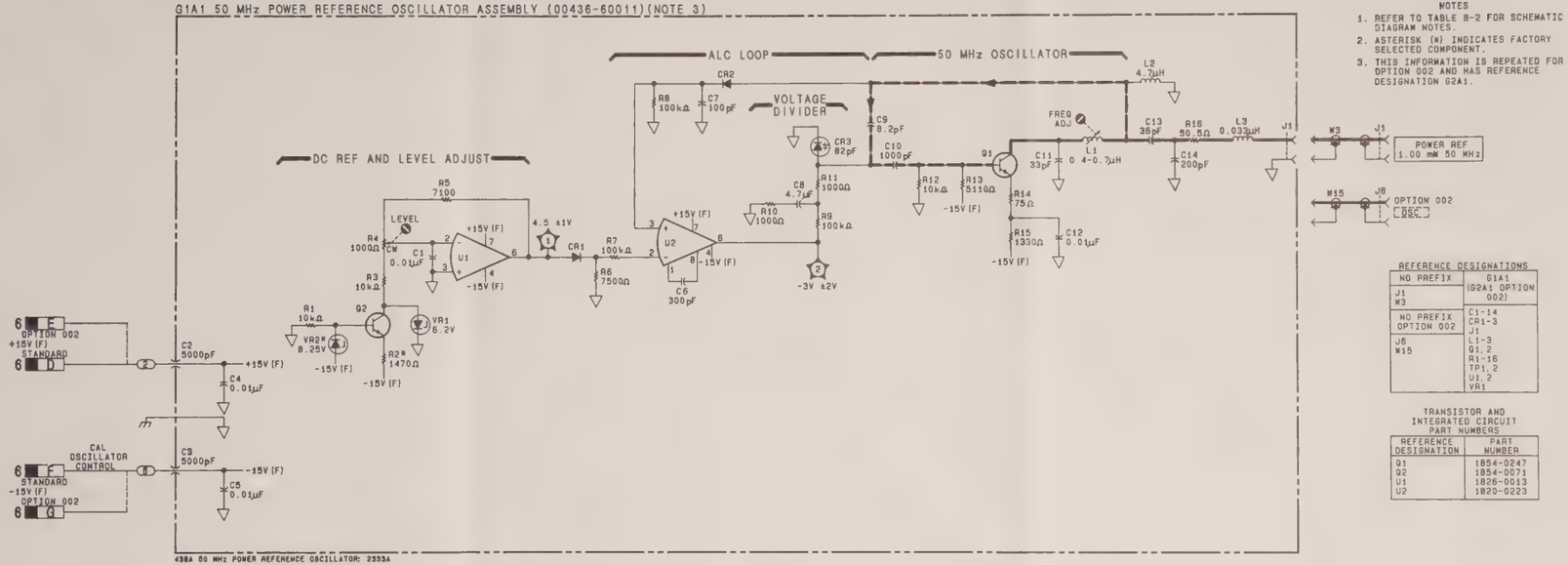

G1A1 50 MHz POWER REFERENCE OSCILLATOR ASSEMBLY (00436-60011)(NOTE 3)
ALC LOOP
50 MHz OSCILLATOR
DC REF AND LEVEL ADJUST
VOLTAGE DIVIDER
OPTION 002 +15V (F) STANDARD
CAL OSCILLATOR CONTROL
STANDARD -15V (F) OPTION 002
438A 50 MHz POWER REFERENCE OSCILLATOR: 2833A
NOTES
1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.
2. ASTERISK (*) INDICATES FACTORY SELECTED COMPONENT.
3. THIS INFORMATION IS REPEATED FOR OPTION 002 AND HAS REFERENCE DESIGNATION G2A1.
POWER REF 1.00 mW 50 MHz
OPTION 002 OSC
REFERENCE DESIGNATIONS
NO PREFIX: G1A1 (G2A1 OPTION 002)
J1 W3
NO PREFIX OPTION 002: C1-14 CR1-3 J1 L1-3 Q1, 2 R1-16 TP1, 2 U1, 2 VR1
J6 W15
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS
REFERENCE DESIGNATION | PART NUMBER
Q1 | 1854-0247
Q2 | 1854-0071
U1 | 1826-0013
U2 | 1820-0223

Figure 8-43. Power Reference Oscillator Circuits Schematic Diagram

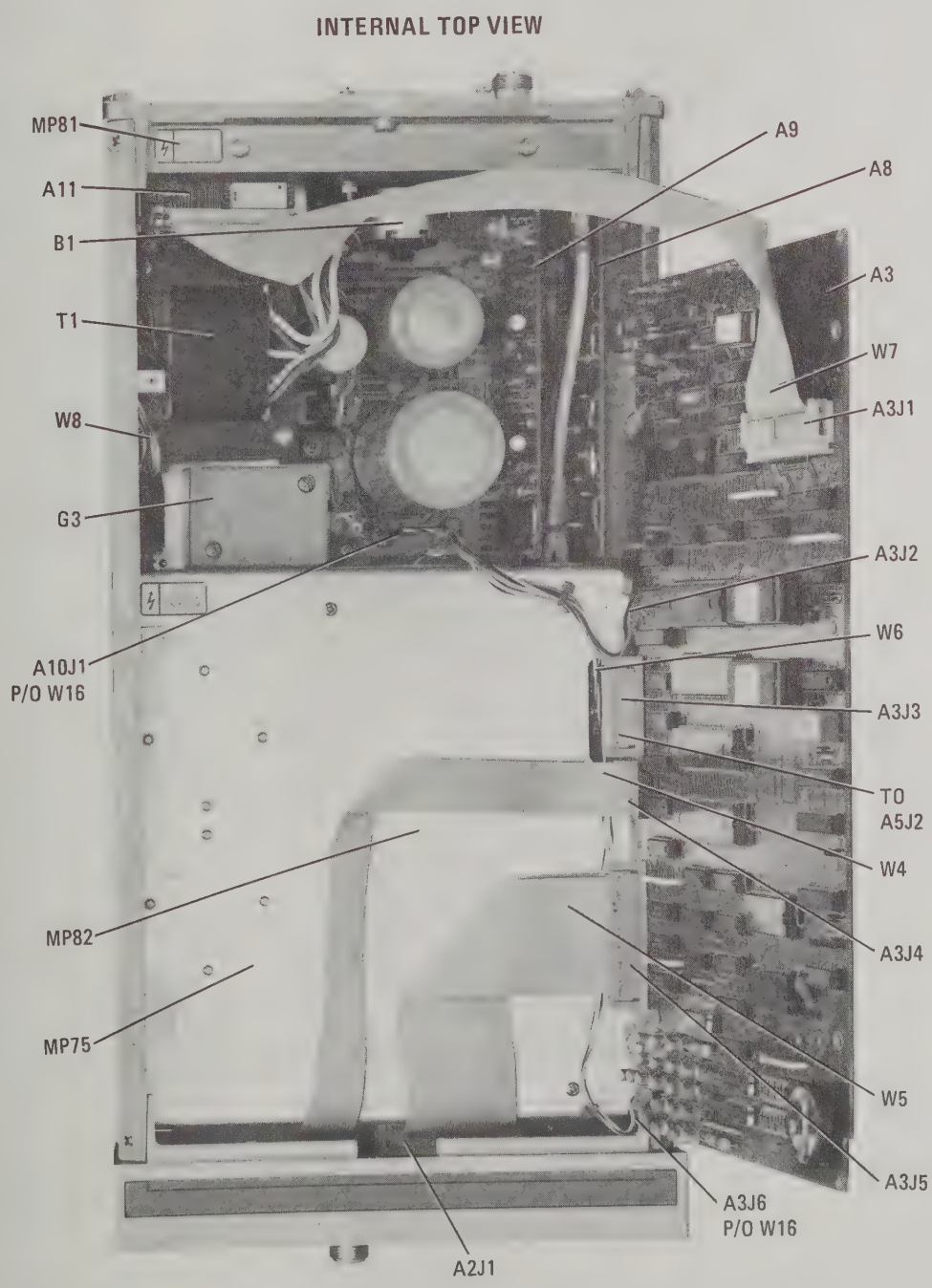


Figure 8-44. Internal Top View

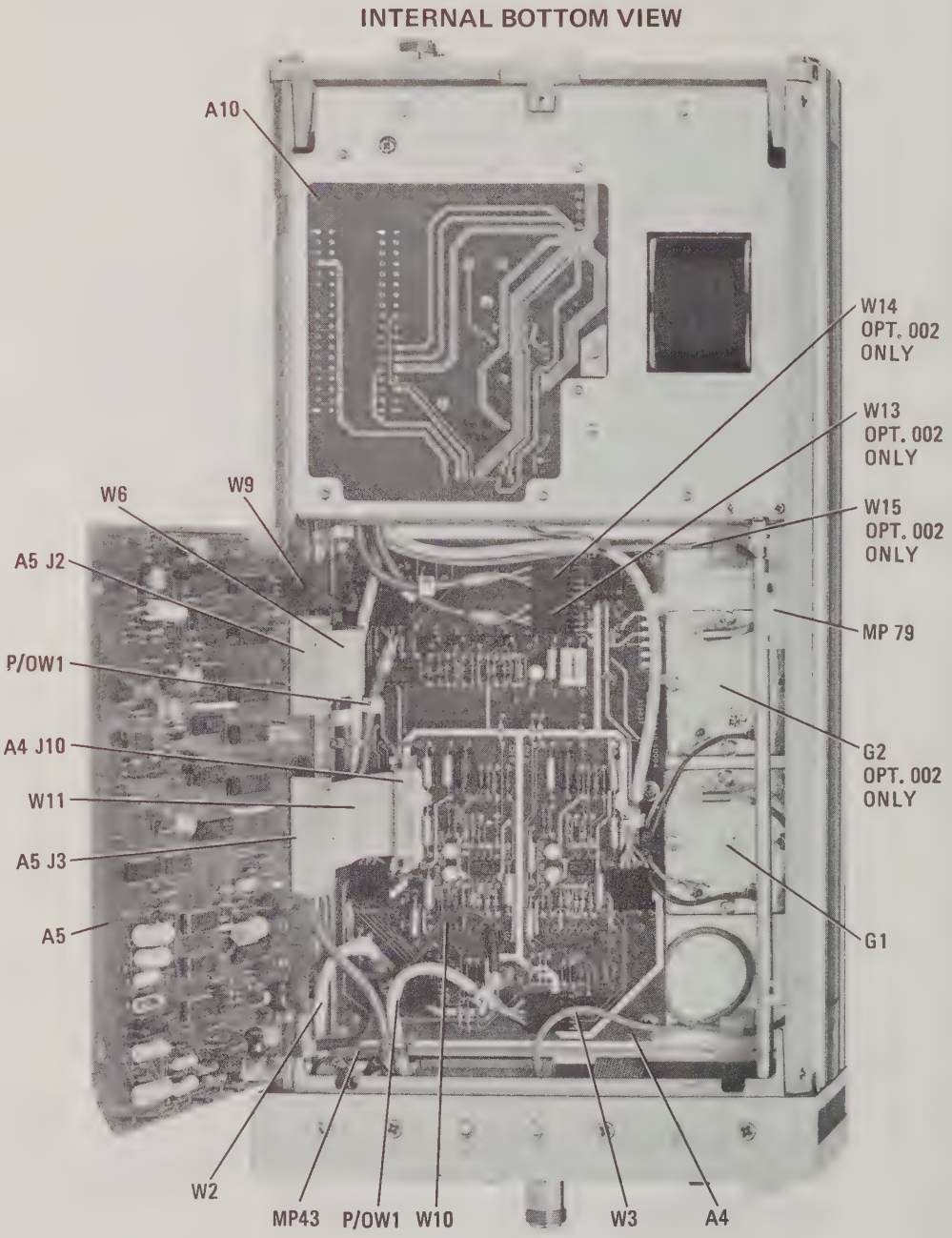


Figure 8-45. Internal Bottom View

HEWLETT PACKARD

Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

COMPANY

ADDRESS

TECHNICAL CONTACT PERSON

PHONE NO. EXT.

MODEL NO. SERIAL NO.

MODEL NO. SERIAL NO.

P.O. NO. DATE

Accessories returned with unit

☐ NONE ☐ CABLE(S)

☐ POWER CABLE ☐ ADAPTER(S)

OTHER _____

over

HEWLETT PACKARD

Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

COMPANY

ADDRESS

TECHNICAL CONTACT PERSON

PHONE NO. EXT.

MODEL NO. SERIAL NO.

MODEL NO. SERIAL NO.

P.O. NO. DATE

Accessories returned with unit

☐ NONE ☐ CABLE(S)

☐ POWER CABLE ☐ ADAPTER(S)

OTHER _____

over

HEWLETT PACKARD

Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

COMPANY

ADDRESS

TECHNICAL CONTACT PERSON

PHONE NO. EXT.

MODEL NO. SERIAL NO.

MODEL NO. SERIAL NO.

P.O. NO. DATE

Accessories returned with unit

☐ NONE ☐ CABLE(S)

☐ POWER CABLE ☐ ADAPTER(S)

OTHER _____

over

HEWLETT PACKARD

Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

COMPANY

ADDRESS

TECHNICAL CONTACT PERSON

PHONE NO. EXT.

MODEL NO. SERIAL NO.

MODEL NO. SERIAL NO.

P.O. NO. DATE

Accessories returned with unit

☐ NONE ☐ CABLE(S)

☐ POWER CABLE ☐ ADAPTER(S)

OTHER _____

over

HEWLETT PACKARD

Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

COMPANY

ADDRESS

TECHNICAL CONTACT PERSON

PHONE NO. EXT.

MODEL NO. SERIAL NO.

MODEL NO. SERIAL NO.

P.O. NO. DATE

Accessories returned with unit

☐ NONE ☐ CABLE(S)

☐ POWER CABLE ☐ ADAPTER(S)

OTHER _____

over

HEWLETT PACKARD

Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

COMPANY

ADDRESS

TECHNICAL CONTACT PERSON

PHONE NO. EXT.

MODEL NO. SERIAL NO.

MODEL NO. SERIAL NO.

P.O. NO. DATE

Accessories returned with unit

☐ NONE ☐ CABLE(S)

☐ POWER CABLE ☐ ADAPTER(S)

OTHER _____

over

Service needed

☐ CALIBRATION ONLY

☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

_____

_____

_____

_____

_____

_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

9320-3896 Printed in U.S.A.

Service needed

☐ CALIBRATION ONLY

☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

_____

_____

_____

_____

_____

_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

9320-3896 Printed in U.S.A.

Service needed

☐ CALIBRATION ONLY

☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

_____

_____

_____

_____

_____

_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

9320-3896 Printed in U.S.A.

Service needed

☐ CALIBRATION ONLY

☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

_____

_____

_____

_____

_____

_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

9320-3896 Printed in U.S.A.

Service needed

☐ CALIBRATION ONLY

☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

_____

_____

_____

_____

_____

_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

9320-3896 Printed in U.S.A.

Service needed

☐ CALIBRATION ONLY

☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

_____

_____

_____

_____

_____

_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

9320-3896 Printed in U.S.A.

REGIONAL SALES AND SERVICE OFFICES

NORTH/CENTRAL AFRICA

Hewlett-Packard S.A.
7, Rue du Bois-du-Lan
CH-1217 **MEYRIN** 2, Switzerland
Tel: (022) 83 12 12
Telex: 27835 hpse
Cable: HEWPACKSA Geneve

ASIA

Hewlett-Packard Asia Ltd.
6th Floor, Sun Hung Kai Centre
30 Harbour Rd.
G.P.O. Box 795
HONG KONG
Tel: 5-832 3211

After Jan. 1, 1984
47th Floor, China Resources Bldg.
26 Harbour Rd., Wanchai
HONG KONG
Telex: 66678 HEWPA HX
Cable: HEWPACK HONG KONG

CANADA

Hewlett-Packard (Canada) Ltd.
6877 Goreway Drive
MISSISSAUGA, Ontario L4V 1M8
Tel: (416) 678-9430
Telex: 610-492-4246

MEDITERRANEAN AND MIDDLE EAST

Hewlett-Packard S.A.
Mediterranean and Middle East Operations
Atrina Centre
32 Kifissias Ave.
Paradissos-Amarousion, **ATHENS**
Greece
Tel: 682 88 11
Telex: 21-6588 HPAT GR
Cable: HEWPACKSA Athens

EASTERN EUROPE

Hewlett-Packard Ges.m.b.h.
Lieblgasse 1
P.O. Box 72
A-1222 **VIENNA**, Austria
Tel: (222) 2365110
Telex: 1 3 4425 HEPA A

NORTHERN EUROPE

Hewlett-Packard S.A.
Uilenstede 475
P.O. Box 999
NL-1180 AZ **AMSTELVEEN**
The Netherlands
Tel: 20 437771

SOUTH EAST EUROPE

Hewlett-Packard S.A.
7, Rue du Bois-du-Lan
CH-1217 **MEYRIN** 2, Switzerland
Tel: (022) 83 12 12
Telex: 27835 hpse
Cable HEWPACKSA Geneve

OTHER EUROPE

Hewlett-Packard S.A.
P.O. Box
150, Rte du Nant-D'Avril
CH-1217 **MEYRIN** 2, Switzerland
Tel: (022) 83 8111
Telex: 22486 hpsa
Cable: HEWPACKSA Geneve

EASTERN USA

Hewlett-Packard Co.
4 Choke Cherry Road
ROCKVILLE, MD 20850
Tel: (301) 258-2000

MIDWESTERN USA

Hewlett-Packard Co.
5201 Tollview Drive
ROLLING MEADOWS, IL 60008
Tel: (312) 255-9800

SOUTHERN USA

Hewlett-Packard Co.
2000 South Park Place
P.O. Box 105005
ATLANTA, GA 30348
Tel: (404) 955-1500

WESTERN USA

Hewlett-Packard Co.
3939 Lankershim Blvd.
P.O. Box 3919
LOS ANGELES, CA 91604
Tel: (213) 506-3700

OTHER INTERNATIONAL AREAS

Hewlett-Packard Co.
Intercontinental Headquarters
3495 Deer Creek Road
PALO ALTO, CA 94304
Tel: (415) 857-1501
Telex: 034-8300
Cable: HEWPACK

HP Part No. 00438-90009

Printed in U.S.A.